CESSNA 150/LYCOMING O-320-E2D LIMITED PERFORMANCE EVALUATION

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FINAL REPORT

Approved for Public Release. Distribution Unlimited

DEPARTMENT OF AERONAUTICS
USAF ACADEMY
UNITED STATES AIR FORCE

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This report presents the results of a limited performance evaluation of the USAF Academy Cadet Competition Flying Team Cessna 150. Each aircraft was fitted with a Lycoming O-320-E2D engine of 150 horsepower. The general objective of this evaluation was to determine the modified Cessna 150 performance characteristics for purposes of generating flight manual performance charts.

Flight test data were reduced and used to develop a computer model of the aircraft using the Reciprocating Engine and Propeller Modeling Program (RPM). This computer model was then used to create performance charts and tabulated data for the flight regimes tested for inclusion in the next update of the Flight Manual.

No changes to existing Flight Manual performance speeds were recommended. Additional testing was recommended to investigate any performance differences between airframes and to further validate the performance charts presented in this report.

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PREFACE

This report presents the results of the limited performance evaluation of the United States Air Force Academy Cadet Competition Flying Team Cessna 150s. In each aircraft, the original Continental O-200 engine was replaced with a Lycoming O-320-E2D engine. This testing was conducted to generate new performance data for inclusion in the aircraft flight manual. This test was accomplished by the Department of Aeronautics for the 94th Flying Training Squadron (FTS). The 94th FTS provided the aircraft and flight time. The Department of Aeronautics provided the flight test aircrew.

Sincere appreciation is expressed to Captain Gerald Peaslee of the 94th FTS and Dale Zawacki and his maintenance crew of UNC Aviation Services for their support in scheduling and maintenance of the aircraft.

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EXECUTIVE SUMMARY

This report presents the results of a limited performance evaluation of the USAF Academy Cadet Competition Flying Team (CCFT) Cessna 150. Each aircraft was fitted with a Lycoming O-320-E2D engine of 150 horsepower in place of the production Continental O-200 of 100 horsepower. This program consisted of 24 flights totalling 41.0 flight hours during the period of 3 July 1995 to 16 May 1996.

The general objective of this evaluation was to determine the modified Cessna 150 performance characteristics for purposes of generating flight manual performance charts. Areas included were pitot-static calibration, and cruise, climb, descent, and takeoff performance. All objectives were met.

Flight test data were reduced and used to develop a computer model of the aircraft using the Reciprocating Engine and Propeller Modeling Program (*RPM*). This computer model was then used to create performance charts and tabulated data for the flight regimes tested for inclusion in the next update of the Flight Manual. Cruise and climb data, including airspeeds, climb rates, engine settings, and fuel flow rates were satisfactorily modeled. Pitot-static corrections, descent data, and takeoff data were reduced and presented using traditional methods.

No changes to existing Flight Manual performance speeds were recommended. Additional testing was recommended to investigate any performance differences between airframes and to further validate the performance charts presented in this report.

The performance of the CCFT Cessna 150 was satisfactorily characterized. Further testing should address the recommendations of this report, and the results of this testing should be incorporated in the Flight Manual.

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INTRODUCTION

BACKGROUND

This test program was requested by the 94th Flying Training Squadron (FTS) to collect flight manual performance data for the Cessna 150 flown by the United States Air Force Academy (USAFA) Cadet Competition Flying Team (CCFT). The Air Force Academy airfield elevation is 6572 feet. To improve performance for operating from the high elevation airfield at the Air Force Academy, the original 100 HP Continental O-200 engine was replaced with a 150 HP Lycoming O-320-E2D engine. As a result, the manufacturer's flight manual performance data were no longer applicable.

The primary operational requirement for this test was determining engine fuel consumption. These data were necessary for determining range and endurance for flight planning. These data were also necessary for CCFT competitions, where fuel burn must be predicted within 10 percent for certain events.

These tests were conducted by members of the USAFA Department of Aeronautics. Aircraft scheduling and maintenance was performed by the 94th FTS. This program consisted of 24 flights totalling 41.0 flight hours during the period of 3 July 1995 to 16 May 1996. Primary flight testing was conducted in the local area around the Air Force Academy. Additional flight testing to verify results at lower altitudes was accomplished between the Air Force Academy and Hays, Kansas.

TEST OBJECTIVE

The general objective of this evaluation was to determine the modified Cessna 150 performance characteristics for purposes of generating flight manual performance charts. Areas included were pitot-static calibration, and cruise, climb, descent, and takeoff performance. All objectives were met.

TEST ITEM DESCRIPTION

The Cessna 150, as operated by the USAFA CCFT, is a two-place general aviation airplane. A three-view drawing of the aircraft is shown in Figure 1. It is powered by one normally aspirated, carbureted, 4-cylinder, 150 horsepower Lycoming O-320-E2D engine driving a MacCauley TM7458/IC172 fixed-pitch propeller. The high wing has an area is 160 square feet and an aspect ratio is 7.0. The maximum takeoff gross weight was 1760 lbs. The flight control system is a reversible flight control system. Each Cessna 150 operated by the USAFA CCFT is considered representative of the other two. These Cessna 150s are not considered production representative of unmodified Cessna 150s. Reference 1 has a more complete description of the CCFT Cessna 150.

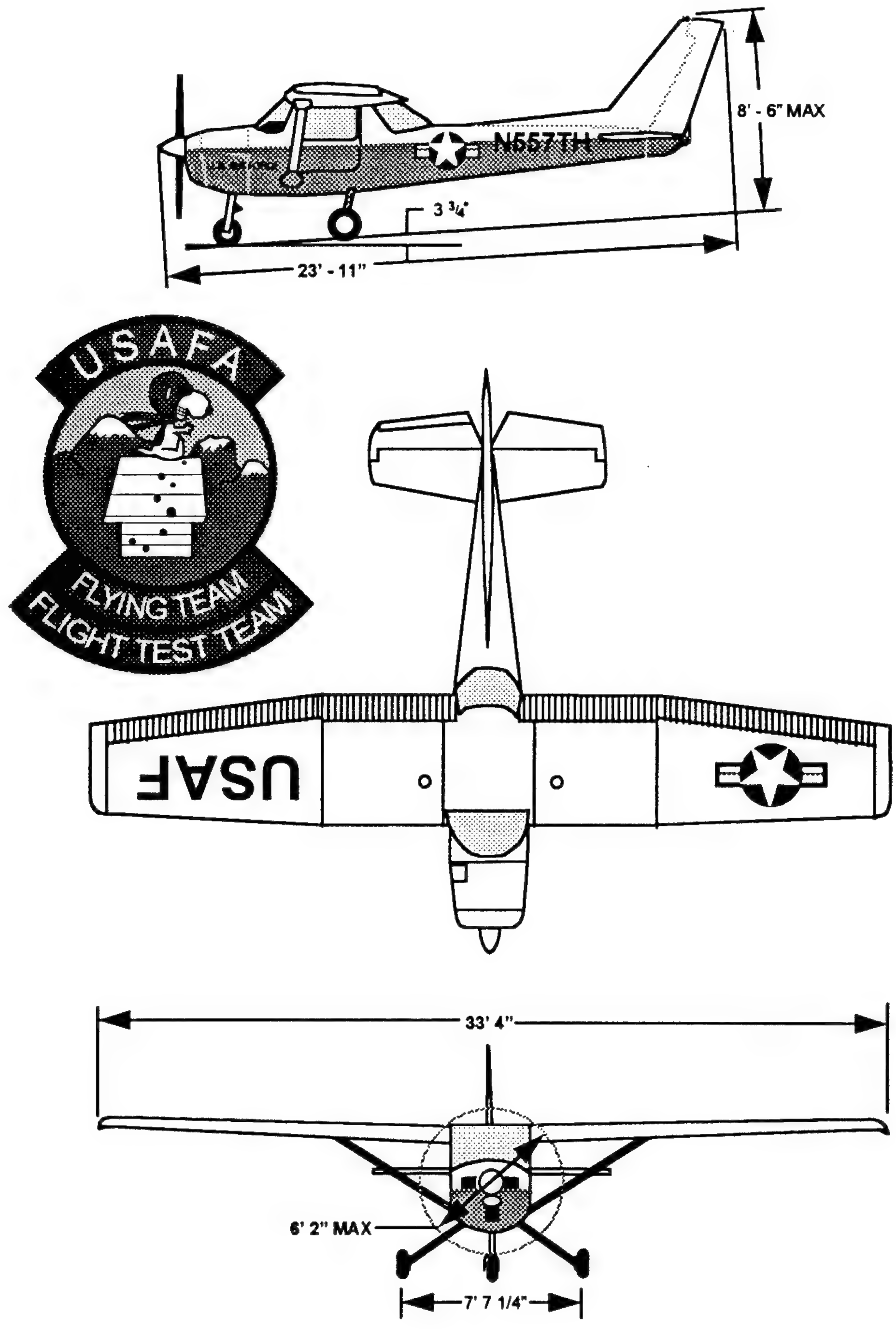

Figure 1 Cessna 150 General Arrangement

TEST AND EVALUATION

GENERAL

Pitot-static calibrations and takeoff, cruise, climb and descent performance tests were conducted. Production instrumentation was used for measuring airspeed, altitude, outside air temperature (OAT), and RPM. A manifold pressure guage was added for flight test in place of the VOR 2 head. A fuel flow/used indicator was installed for use in normal operations. Time was recorded using a digital wristwatch and a Hewlett Packard 48SX calculator. Position was determined from a Garmin GPS 55 handheld Global Positioning System (GPS) receiver. No additional calibration of instruments was accomplished beyond normal Federal Aviation Administration (FAA) Instrument Flight Rules (IFR) requirements.

Flight testing was accomplished in the USAFA local flying areas at pressure altitudes of 8,000 to 12,000 feet. Additional data were collected at lower altitudes near La Junta, CO (6,000 feet), Hays, KS (3,000 feet), and on routes between USAFA, CO and Hays, KS (4,500 - 7,500 feet).

Flight test data were used to create and verify a computer model of the Cessna 150 aircraft, engine, and propeller using the Reciprocating Engine and Propeller Modeling Program (*RPM*). (Reference 2) This computer model was used to expand standardized data to create the flight manual data. Details of the construction of the aircraft model are contained in Appendix C.

CRUISE PERFORMANCE

Test Objectives:

The test objectives for cruise performance were:

1. Determine power settings, fuel flow, range, and endurance as functions of airspeed and altitude.

2. Determine power required and power available as a function of airspeed.

3. Determine the aircraft drag polar.

4. Determine airspeeds for maximum range and for maximum endurance.

5. Create charts and tabulated data for Flight Manual cruise data.

Test Procedures:

Cruise data were collected using steady state trim shots at constant pressure altitude (PA) and airspeeds of 50, 60, 70, 80, 90, and 100 knots. Trim shots were also recorded at the airspeed for full throttle. Data recorded included the indicated altitude (h_i), indicated airspeed (V_i), outside air temperature (OAT), manifold pressure (MAP), engine RPM, start and end time, initial fuel used and final fuel used.

Fuel used was measured by a Hoskins FT101A Fuel Totalizer. Fuel used was reported to the nearest tenth of a gallon. This indicator normally displayed fuel flow, which varied too much to be usable for this test. This variation arose primarily from the actual variation in fuel flow as the carburetor float opened and closed the fuel inlet valve to the carburetor bowl. Fuel used could be read by pressing a button on the indicator. After displaying the fuel used for a few seconds, the display would revert to fuel flow.

To improve the accuracy of the fuel used measurement, the flight test engineer pressed the button on the indicator each time the display reverted to fuel flow. This resulted in a reasonably constant display of fuel used. Timing for each test point was begun or ended as the tenths digit changed. Test points were flown long enough to burn exactly 0.5 gallons. Further information on fuel measurement can be found in Appendix D.

Cruise data were reduced using the P_{iw} - V_{iw} method and other cruise data reduction methods shown in Appendix D.

Test Results:

Flight Test Data Reduction.

Cruise data were collected as described above. Additionally, MAP and RPM data were used from

Pitot-static test points. These data increased the amount of data available for determining drag and power required, but did not include fuel flow data.

The drag and power required were determined using engine horsepower and propeller efficiency. The engine horsepower was determined from MAP, RPM, h_i, and OAT, using the engine chart as described in Appendix C. Propeller efficiency was determined from RPM and true airspeed (V), using the propeller chart as described in Appendix C.

N557TH was the only aircraft to have a MAP gauge installed, and not for all flights. On flights when a MAP gauge was not available, engine horsepower was determined using the propeller power coefficient. Figure A1 compares the horsepower calculated by each method for test points where a MAP gauge was available. Ideally, all points would lie on the line with a slope of 1:1. The match between the two methods is satisfactory, especially considering that the propeller model is fairly simple, with only inputs of blade shape, diameter, and pitch.

The drag polar was determined by a linear least squares curve fit to the drag coefficient (C_D) versus the square of the lift coefficient (C_L), as shown in Figure A2. This technique assumed a drag polar of the form

$$C_D = C_{D_o} + KC_L^2$$

with no linear C_L term. The aircraft drag polar was

$$C_D = 0.042696 + 0.068861\ C_L^2$$

While this drag polar reports more significant figures than can be justified from the flight test data, this drag polar is reported as the drag polar used in the *RPM* model.

Given the aspect ratio of 7.0, this drag polar indicates an Oswald's efficiency factor of 0.66. The parasite drag coefficient is also higher than normally seen for general aviation aircraft. This difference is suspected to be caused by separation drag from the rear window. This separation is suspected again later when explaining the climb results.

Figure A3 compares the drag results from aircraft N557TH, the primary test aircraft, with the drag polar. These data are in agreement with the drag polar. Drag data from two flights in N557AW are shown in Figure A4, again with good agreement. Drag data from N557SH were not originally in good agreement with the drag polar. After applying a different position correction to the N557SH data, as suggested from the Pitot-static tests, the agreement was improved to an acceptable level, as shown in Figure A5. Additional testing should be conducted to verify the validity of the drag polar for all three aircraft. (R1)[1]

The brake horsepower required by a linear least squares curve fit to the product of standardized brake horsepower and standardized equivalent airspeed ($BHP_{iw}V_{iw}$) versus standardized equivalent airspeed raised to the fourth power (V_{iw}^4), as shown in Figure A6. This technique also assumes a drag polar of the form shown earlier and a negligible change in the propeller efficiency between the test data point and the standardized data point. Using this curve fit, the brake horsepower required was calculated, as shown in Figure A7 through Figure A9. These figures also show that the brake horsepower required results from each aircraft agree with the brake horsepower required curve in the same manner as the drag results with the drag polar.

Figure A10 shows the fuel consumption results as brake specific fuel consumption (BSFC) plotted against brake horsepower. BSFC is normally considered as a constant with respect to brake horsepower. Thus, Figure A10 shows BSFC results for all cruise points, from pressure altitudes of 3,000 to 9,000 feet. The fairings are derived from *RPM* model data at cruise conditions at altitudes from sea level to 15,000 feet. According to the *RPM* model, the BSFC for a given brake horsepower will change slightly with altitude. However, all of these fairings are well within the boundaries of the scatter of the data, and are therefore considered reasonable.

Figure A11 shows the results for specific air range (SAR) for all cruise data collected at all altitudes. Specific air range can be expressed as

$$SAR = \frac{\eta_p}{BSFC}\frac{C_L}{C_D}\frac{1}{W} = \frac{V}{\dot{w}_f}$$

[1] Numerals preceded by an "R" in parentheses at the end of a paragraph correspond to the recommendation numbers tabulated in the Conclusions and Recommendations section of this report.

If the propeller efficiency (η_p) and the BSFC are considered constant with altitude for a given equivalent airspeed, then SAR should be independant of altitude. In practice and according to the *RPM* model, propeller efficiency does remain constant, but BSFC will vary slightly, as shown in Figure A10. Thus, the fairings derived from *RPM* model data at cruise conditions at altitudes from sea level to 15,000 feet show a variation similiar to the variation seen in the BSFC data. Again, all of the SAR fairings are within the boundaries of the scatter of the data, and are therefore considered reasonable.

Figure A12 shows the results for specific endurance (SE) for all cruise data collected at all altitudes. Specific endurance can be expressed as

$$SE = \frac{\eta_P}{BSFC} \frac{C_L^{3/2}}{C_D} \left(\frac{\rho S}{2}\right)^{1/2} \frac{1}{W^{3/2}} = \frac{1}{\dot{w}_f}$$

Since density appears explicitly in this equation, SE will be a function of altitude. Figure A12 does not attempt to break out the SE data by altitude, as the variation with altitude, shown by the fairings from *RPM* data, is smaller than the scatter of the data. Any adjustments to improve the fit of SE data would be accomplished by improving the fit of the fuel flow data, which also affects BSFC. If the modeling of the fuel flow data is satisfactory, then the modeling of SE and BSFC will be satisfactory. Again, all of the SE fairings are within the boundaries of the scatter of the data, and are therefore considered reasonable.

RPM Model Generation.

A computer model of the performance of the aircraft was generated using the Reciprocating Engine and Propeller Modeling Program (*RPM*). The airframe was modeled using the drag polar derived from flight test data. The engine model and propeller model were adjusted until a satisfactory fit was obtained with flight test MAP, RPM, and fuel flow data. The process of this adjustment and the resulting model data files are described in detail in Appendix C.

Predicted Aircraft Performance.

The *RPM* model was used to create performance charts similar to those seen in the Flight Manual for a general aviation aircraft. Figure A13 shows the cruise true airspeed as a function of density altitude and power setting. To use this chart, start with the OAT, go straight up to the pressure altitude, go straight across to the power setting, then straight down to read the true airspeed. For the example shown:

OAT:	40° F
Pressure Altitude:	8,000 feet
Power Setting:	60%
True Airspeed:	102 KTAS

Figure A14 relates RPM to power setting as a function of density altitude. To use this chart, start with the OAT, go straight up to the pressure altitude, go straight across to the power setting, then straight down to read the RPM. For the example shown:

OAT:	40° F
Pressure Altitude:	8,000 feet
Power Setting:	60%
RPM:	2345

Appendix D shows that true airspeed and RPM remain the same for an aircraft in cruise flight at the same density altitude, power setting, and weight. Thus, the density altitude can be used to account for non-standard conditions.

Figure A15 shows the cruise fuel flow as a function of pressure altitude, power setting, and OAT. To use this chart, start with the pressure altitude, go straight across to the power setting, then straight down to the zero temperature deviation line. Follow the guidelines (up for OAT above standard, down for OAT below standard) by the amount of temperature deviation from the standard temperature for the pressure altitude. Then go straight down to read the fuel flow. For the example shown:

Pressure Altitude:	8,000 feet
Power Setting:	60%
OAT:	Std + 60° F
Fuel Flow:	8.6 gal/hr

Appendix D discusses the correction to fuel flow for non-standard temperatures.

Table A1 tabulates the cruise performance for various altitudes, airspeeds, and temperatures. Values for manifold pressure, percent power, RPM, true airspeed, and fuel flow are given for each flight condition. This table was reproduced on 5x8" cards

for the flight crews for flight planning purposes, without the manifold pressure and percent power information. Power settings above 75 percent were flagged. Cards were produced with data at each 1000 feet of altitude. Cards were also produced corresponding to Visual Flight Rules (VFR) hemispheric altitudes (each 1000 feet + 500 feet). Images of these cards are shown in Appendix B.

Table A2 shows the same information as Table A1, except that data is arranged by RPM, not indicated airspeed. This format is similar to that used in Cessna Flight Manuals.

Figure A16 through Figure A23 show the range and endurance for cruise at a constant indicated airspeed. Data are shown for dual and solo flight. Both conditions assume takeoff at maximum gross weight. Takeoff at less than maximum gross weight (with the same amount of fuel) would result in longer range and endurance. Table 1 details the assumptions for the dual and solo scenarios.

Table 1

RANGE AND ENDURANCE SCENARIOS

Parameter	Dual	Solo
Empty Weight	1249 lbs	1249 lbs
Aircrew	2 (340 lbs)	1 (170 lbs)
Baggage	15 lbs	113 lbs
Unusable Fuel	3 gal	3 gal
Useable Fuel	23 gal	35 gal
Startup, Taxi, Takeoff, and Climb Fuel	2 gal	2 gal
Climb Distance	10 nm	10 nm
Climb Time	8 min	8 min

The range and endurance charts were created using the *RPM* model. After setting the aircraft weight and useable fuel, the fuel consumption was computed in 10 minute time intervals. Between each interval, the aircraft and engine were retrimmed to account for reduction in drag arising from the reduction in weight. This process was continued until all of the useable fuel was consumed. Figure A16 through Figure A23 include the climb distance and climb time shown in Table 1. No distance or time for descent were included in these charts.

To use the range charts, start with the OAT, go straight up to the pressure altitude, go straight across to the indicated airspeed, then straight down to the zero temperature deviation line. Follow the guidelines (up for OAT above standard, down for OAT below standard) by the amount of temperature deviation from the standard temperature for the pressure altitude. Then go straight down to read the range. For the example shown:

OAT:	80° F
	Std + 35° F
Pressure Altitude:	4,000 feet
Indicated Airspeed:	80 KIAS
Range:	315

Appendix D explains the corrections to range for non-standard conditions.

To use the endurance charts, start with the pressure altitude, go straight across to the indicated airspeed, then straight down to the zero temperature deviation line. Follow the guidelines (up for OAT above standard, down for OAT below standard) by the amount of temperature deviation from the standard temperature for the pressure altitude. Then go straight down to read the endurance. For the example shown:

Pressure Altitude:	4,000 feet
Indicated Airspeed:	80 KIAS
OAT:	Std + 35° F
Endurance:	3.7 hr

Appendix D discusses the correction to endurance for non-standard temperatures.

Figure A24 shows the brake horsepower required and available at altitudes from sea level to 15,000 feet. This figure was created using the *RPM* model. To determine other performance parameters, propeller efficiency was applied to the curves of Figure A24 to calculate thrust horsepower required and available, shown in Figure A25. From this chart, thrust required and available were calculated, shown in Figure A26.

Table A3 shows the airspeed for maximum range as determined by three methods at sea level and 10,000 feet. Assuming constant propeller efficiency and BSFC, maximum range for a propeller driven aircraft occurs at the airspeed for maximum L/D. (Reference 5) Thus, the airspeed for maximum range would be found at the minimum of the thrust required curve

(Figure A26) or at the tangent from the origin to the thrust horsepower required curve (Figure A25). This method gives an indicated airspeed of 56 KIAS.

Using the SAR shown in Figure A11, the SAR is a maximum at 73 KIAS at sea level and 68 KIAS at 10,000 feet. These values of SAR are for maximum gross weight at a given standardized airspeed. As the weight decreases, the standardized airspeed corresponding to a constant indicated airspeed will increase. Increasing standardized airspeed from the airspeed for maximum SAR will reduce the SAR. Therefore, for an overall maximum range, the indicated airspeed would be less than the values indicated on this chart. Additionally, changes in propeller efficiency or BSFC as weight decreased would change the values of SAR.

According to the range charts (Figure A16 and Figure A20), the maximum range occurs at 65 KIAS for both dual and solo flight. The range at 56 KIAS is not shown in Figure A16 since it was less than the maximum, but the range at 56 KIAS was only 8 to 11 nautical miles less than the range at 65 KIAS, depending on altitude. Assuming an approximate range of 300 nautical miles, this difference would be 3 to 4 percent. At 73 KIAS, Figure A16 suggests the difference in range to be 0 to 5 nautical miles shorter than the range at 65 KIAS. This difference would be under 2 percent. Thus, each method results in an airspeed giving a range within 4 percent of the other methods. Since this method used to create Figure A16 accounts for the changes in weight during cruise, 65 KIAS was probably the most accurate airspeed for maximum range, even though the change in range is very small with airspeed around 65 KIAS. Therefore, 65 KIAS was chosen as the airspeed for maximum range.

Flying at maximum range airspeed is typically too slow for operational considerations. Table A4 shows the effect on range of flying at higher speeds at typical cruise altitudes of 5,000 and 10,000 feet. Reference 6 suggests that the airspeed for maximizing airspeed per amount of fuel burned, and thus the most efficient cruise speed considering time and fuel use, is found at the tangent from the origin to the thrust required line. Figure A26 shows this airspeed to be 85 KCAS. This airspeed corresponds to 86.5 KIAS. However, for ease of reading the range charts and operational simplicity (the airspeed indicator has a mark at 85 KIAS), this airspeed was investigated at 85 KIAS. Flying at 85 KIAS increases the airspeed by 20 KIAS, with only a 10 to 20 percent reduction in range.

Table A4 also shows range performance for the typical operational technique practiced at the 94th FTS. Flight time has an operational cost since the maximum flight time allowable per day is limited, thus limiting the total range available per day. Additionally, flight time has a monetary cost in per diem payments for TDY aircrew. Since fuel cost is typically negligible compared to the cost associated with flight time, flights are typically conducted at maximum airspeed, either at 75 percent power or full throttle if 75 percent power is not attainable. At 5,000 feet density altitude, 75 percent power yields an indicated airspeed of 105 KIAS and a 34 to 40 percent reduction in range. At 10,000 feet density altitude, full throttle yields 90 KIAS and a 23 to 25 percent reduction in range.

The airspeed for maximum endurance can also be determined three ways: the minimum power required, the maximum specific endurance, and the largest calculated endurance from the *RPM* model. In each of these cases (Figure A12, Figure A18, Figure A22, and Figure A25) the maximum endurance airspeed is shown to be the minimum speed tested, or 50 KIAS. Although slightly more endurance would probably be possible at a slower speed, 50 KIAS is the minimum practical endurance speed for holding, considering the Flight Manual reported stall speed of 47 KIAS.

Flight data, such as RPM, fuel flow, fuel used, indicated airspeed, true airspeed, range, and endurance should be collected on 94th FTS deployments and CCFT practice and competition flights and compared to the performance data presented in this report for further verification of these performance data. (R2)

PITOT-STATIC CALIBRATION

Test Objectives:

The test objectives for Pitot-static calibration were:

1. Complete a calibration of the production Pitot-static system.

2. Verify Pitot-static corrections given in the Flight Manual.

Test Procedures:

GPS Speed Course Method.

This Pitot-static calibration method was an adaptation of the traditional ground speed course method (Reference 3). Instead of using landmarks to determine distance, GPS distance-to-go readings were used. These distance-to-go readings were based on a waypoint at least 30 nm away. This waypoint was chosen such that the heading directly toward or away from the waypoint would be approximately perpindicular to the wind. The aircraft was flown on a heading directly toward and away from the waypoint with no wind drift correction. For each airspeed tested, the time to fly four nautical miles (ground distance) was recorded in each direction. Additionally, h_i, V_i, OAT, MAP, RPM, and fuel used were recorded. The true airspeed was assumed to be equal to the average ground speed for runs toward and away from the waypoint. From this true airspeed the position correction was determined. For this testing, airspeed and altitude instrument errors were assumed to be negligible. A more complete description of this technique and the data reduction are shown in Appendix D.

GPS Ground Speed Method.

The GPS ground speed method was developed at the USAF Test Pilot School (USAF TPS), and became known to the test team during the flight test phase of this project (Reference 4). Additional Pitot-static testing was completed to compare the relative position errors of different CCFT aircraft, and at the request of USAF TPS for further development of this method.

In this method, the aircraft true airspeed was estimated based on indicated airspeed, estimated position correction, pressure altitude, and outside air temperature. Starting on a heading with an expected headwind or tailwind, a slow turn was initiated. The turn was continued until the GPS ground speed matched the calculated true airspeed. At this point the aircraft should be heading perpindicular to the wind. The aircraft was then turned 180 degrees to confirm the same ground speed. These headings were then used for the data collection.

The aircraft was flown at the aim airspeed and altitude on the crosswind heading. The primary data collected were V_i, heading, GPS ground speed, and GPS track angle. Additionally, h_i, OAT, MAP, RPM, and fuel used were collected. The primary data were recorded multiple times for approximately one minute to detect any variations from outside effects such as wind gradients. The same data were collected for the same flight conditions on the opposite heading. The true airspeed was determined by multiplying the GPS ground speed by the cosine of the angle difference between the heading angle and the GPS track angle (i.e. the drift angle). For this testing, airspeed and altitude instrument errors were assumed to be negligible. A more complete description of this method and the data reduction are shown in Appendix D.

Test Results:

Figure A27 shows the flight test derived position correction curve compared with the flight test data and the Flight Manual position correction curve. The flight test derived curve seems reasonable, as it follows the general trend of the Flight Manual curve. The flight test data shown in this figure were all collected in N557TH. Pitot-static data were collected in this aircraft on flights 1, 5, 6, 7, 10, 22, and 23. The flight 1 data are not shown as they were significantly different from all later flights and did not pass the reasonableness test. On flight 1, Pitot-static data were collected using the GPS Speed Course method, but with legs only one nautical mile in length. Prior to flight 5, the test team decided that legs of at least four nautical miles in length were necessary to reduce possible errors to an acceptable level. (See Appendix D)

Pitot-static data was collected using the GPS Speed Course method on flights 5, 7, and 10. The data shown for flight 5 have a similar slope to the final position correction curve, but were displaced down from the curve by two to four knots. These data were weighted less heavily than the rest, since the leg times implied that the legs were not being flown perpindicular to the wind. Thus, the data was suspected to have been corrupted by wind effects.

Starting with flight 7, more care was taken to ensure that legs were flown perpindicular to the wind. The data from flights 7 and 10 agreed well, and were used to create the position correction curve. The leg times showed that wind effects were minimal for these flights.

No Pitot-static data points had been collected to this time at 50 KIAS, so these were picked up on flights 22 and 23. These data were collected using the GPS Ground Speed method, which had become known to the test team by this point. These two data points agreed very well with the slope implied by the previous data points at 60 and 70 KIAS.

Further confidence was gained in the flight test derived position correction curve when drag polar data and power required data fell into the shapes expected from theory. Using prior position correction curves, such as the curves used based on flight 1 or flight 5 data, the drag polar and power required data did not follow the generally linear trend seen in Figure A2 and Figure A6. When the final position correction was used, the data lined up as shown in these figures with no further compensation.

The CCFT normally plans its competition navigation legs at 90 KIAS. At this airspeed, the flight test derived position correction is only one knot different from the Flight Manual position correction, well within the scatter of the data. The negative value also correlates with historical experience by the CCFT of seeing "higher than expected headwinds" in practice and competition. Failure to correct for the Pitot-static position error would result in the aircraft flying slower than was planned for. Additionally, most cross country flights by the 94 FTS are flown at full throttle or 75 percent power, whichever is lower. In this range of airspeeds, the flight test and Flight Manual position corrections are within a knot of each other. However, at low airspeeds, the flight test position correction is about 6 knots higher than the Flight manual position correction. This will result in a conservative error, with the aircraft on the proper approach indicated airspeed actually flying at a higher calibrated airspeed than predicted by the flight manual. Since operations at the 94 FTS have been successful over the years, there is no reason to change the Flight Manual takeoff or approach speeds.

Figure A28 shows the altitude position correction curve at sea level from flight test and the Flight Manual. These curves were derived from the airspeed position correction curve, using the equation from Reference 3:

$$\Delta H_{pc} = \frac{-\Delta P_s}{\rho g} = \frac{1}{2\sigma g}\left(CAS^2 - IAS^2\right)$$

While this correction varies slightly with altitude, the small values of ±30 feet are not operationally significant, and can be ignored for normal operations.

All preceding Pitot-static data were collected on N557TH. Additional investigation was conducted to determine if noticeable differences existed in the Pitot-static errors between the three CCFT aircraft. One test point was flown using the GPS Ground Speed method in N557AW, but was rejected for excessive wind error. However, all drag polar and cruise data collected in N557AW (Figure A4 and Figure A8) matched the data of N557TH within the experimental scatter using the same position correction curve. Therefore, the flight test derived position correction curve was considered valid for both N557TH and N557AW.

The flight test derived position correction curve did not work as well for N557SH. Figure A29 shows the curve along with Pitot-static data collected in N557SH. These data were collected using the GPS Ground Speed method. While the flight test data do not match the curve, the data do have the same basic shape. For N557SH, an acceptable position correction could be found by subtracting 4 knots from the flight test derived position correction curve, as shown in Figure A29. This finding correlates with operational experience that N557SH flying side by side with either of the two other aircraft would show a higher indicated airspeed. Investigate the Pitot-static position corrections for N557SH and N557AW. (R3)

The test team found the GPS Ground Speed method to be superior to the GPS Speed Course method in both test efficiency and data quality. Test points could be accomplished much faster using the GPS Ground Speed method, and did not require maintaining a stable airspeed as long as in the GPS Speed Course method. Since the legs were shorter, it was easier to avoid local air disturbances such as thermals or upslope winds. Since the method includes a technique for approximating a crosswind heading, wind effects from incorrect winds aloft forecasts are minimized. Additionally, the data can be evaluated by inspection for wind effects such as not being on a crosswind heading or wind gradients. GPS Speed Course data required calculations to determine effects of not being on crosswind heading, and did not indicate wind gradients in any way.

CLIMB PERFORMANCE

Test Objectives:

The test objectives for climb performance were:

1. Determine maximum rate of climb at full throttle.

2. Determine the airspeed for maximum rate of climb at full throttle.

3. Determine rate of climb as a function of airspeed at full throttle.

4. Determine best angle of climb at full throttle.

5. Determine the airspeed for best angle of climb at full throttle.

6. Determine time to climb, distance to climb, and fuel to climb as a function of altitude.

7. Create charts for Flight Manual climb data.

Test Procedures:

Climb data were collected using the sawtooth climb FTT (Reference 3). Full throttle constant airspeed climbs were conducted at 50, 60, 65, 70, 80, and 90 KIAS. For each test point, two climbs were flown on opposite headings perpendicular to the wind. Times were recorded every 100 feet of pressure altitude using the time function of the Hewlett Packard 48SX calculator. Climb data were reduced as shown in Appendix D.

Test Results:

Figure A30 and Figure A31 show the standard day rate of climb performance in terms of indicated and calibrated airspeed. Each figure shows lines indicating the best rate of climb airspeed and best angle of climb airspeed as they vary with altitude. While the values in indicated airspeed are more useful operationally, the values in calibrated airspeed are shown to justify the best angle of climb airspeed. The best angle of climb airspeed can be found at the tangent line from the origin to the rate of climb curve. This determination can be done on a rate of climb chart plotted against calibrated, equivalent, or true airspeed, since in each case the entire line for a given altitude is multiplied by the same factor regardless of airspeed. However, this determination cannot be performed on a rate of climb chart plotted against indicated airspeed. The shape of the curve changes since the conversion from calibrated to indicated airspeed is non-linear and dependent upon airspeed. The best angle of climb airspeeds were found using the chart plotted against calibrated airspeed, and these calibrated airspeeds were converted to indicated airspeeds and plotted on Figure A30.

The flight test derived climb speeds compare to the Flight Manual climb speeds as shown in Table 2. In converting between indicated and calibrated airspeed, the flight test derived Pitot-static position correction was used for flight test data, and the Flight Manual correction was used for Flight Manual data. The resulting rates and angles of climb are shown in Table 3.

Table 2

CLIMB SPEED COMPARISON (IN KIAS (KCAS))

	Best Angle		Best Rate	
Altitude	Flight Test	Flight Manual	Flight Test	Flight Manual
Sea Level	54 (60)	56 (56)	71 (72)	68 (66)
10,000 ft	50 (58)	56 (56)	59 (64)	62 (61)

Table 3

MAXIMUM PERFORMANCE CLIMB RESULTS (Standard Day, Standard Weight)

	Best Angle		Best Rate	
Altitude	Airspeed (KIAS)	Angle (deg)	Airspeed (KIAS)	Rate (ft/min)
Sea Level	56	7.5	65	865
10,000 ft	56	2.6	65	330

Comparing climb speeds in calibrated airspeed, the flight test results for best angle of climb are 2 to 4 knots faster than recommended in the Flight Manual. Flight test best rate airspeeds are 3 to 6 knots faster than recommended in the Flight Manual. Flying at the Flight Manual recommended speed for best angle will result in a climb angle of 7.2 degrees at sea level for a 0.3 degree (4 percent) loss of climb angle. The Flight Manual recommended speed for best rate will result in a rate of climb of 850 ft/min at sea level for a 15 ft/min

(less than 2 percent) loss of climb rate. These differences are small enough that no changes in the Flight Manual are warranted.

Climb data is also presented for a cruise climb at 80 KIAS, which increases distance flown at a small loss of climb rate (2 percent at sea level, increasing to 26 percent at 10,000 feet) for situations where the maximum rate of climb is not required. Additionally, climbing at 80 KIAS improves the pilot's forward visibility by lowering the pitch angle.

The climb data were analyzed using the *RPM* model. Since the *RPM* model will simulate non-standard atmospheric conditions, it was assumed that if the model could be made to match the flight test data at several non-standard conditions, then the model would be considered good and valid for any atmospheric conditions. Figure A32 shows climb data for two flight conditions, one at 8,000 feet and one at 12,000 feet pressure altitude and temperatures close to standard day temperatures. The *RPM* model was adjusted to closely match the 8,000 foot data, and then compared to the 12,000 foot data. The fairings in Figure A32 represent the *RPM* model prediction. The *RPM* model data were considered to be in reasonable agreement with the 12,000 foot data.

Figure A33 shows climb data for two flight conditions, one at 6,000 feet and one at 8,000 feet pressure altitudes and temperatures significantly above standard day temperatures. Climb data from the same *RPM* model is shown to be in reasonably good agreement with the flight test data. The maximum deviation from the flight test data is 50 ft/min, which is only 1/2 a division on a Vertical Velocity Indicator (VVI). The *RPM* model produced a valid representation of the aircraft climb performance.

To get the *RPM* model data to match the climb data, two additional compensations were made within the computer program. The first was to account for expanding pressure contours on non-standard days. On a hotter than standard day, 1000 feet of pressure altitude is greater than 1000 feet of tapeline altitude. Therefore, a rate of climb expressed in terms of pressure altitude will be less than the same rate of climb expressed in terms of tapeline altitude. This compensation was merely an application of a principle normally used in climb data reduction.

The second compensation was to account for an apparent increase in aircraft drag in climbs over that seen in cruise flight. This difference in drag was more noticeable at low speeds and less noticeable at high speeds. This result was hypothesized to be a result of the interaction of the slipstream and the separation drag from the cockpit rear window. The steeply sloping rear window is known to cause separated flow and thus increase the aircraft drag. Additionally, this window is fully engulfed in the propeller slipstream. At low speeds, the difference between the induced velocity of the propeller at full power and cruise power is the greatest, reducing to no difference at maximum airspeed. Therefore, the slipstream velocity over the rear window would be much higher in a slow speed climb than in cruise flight at the same airspeed. A relationship was developed and applied to the model data to account for this extra drag. This relationship and the method for accounting for non-standard day pressure altitude variations are further described in Appendix C.

Because the sawtooth climbs were relatively short compared to the amount of fuel burned, fuel used during the climb was not recorded. The fuel flows were calculated by the *RPM* model using the same fuel flow calculation method from cruise flight as a function of engine MAP and RPM.

Figure A34 through Figure A39 show rate of climb, fuel flow, time to climb, fuel to climb, and distance to climb at 65 KIAS and 80 KIAS. These charts are also submitted for Flight Manual inputs in Appendix B. These charts represent the *RPM* model and will give values for non-standard conditions. To determine rate of climb, enter the bottom left side of the chart at the appropriate OAT, go up to the pressure altitude, across to the rate of climb line, and straight down to read the rate of climb. The variation of fuel flow with non-standard temperature and pressure are almost identical to the rate of climb variation, so both of these values are plotted on the same chart. For the example shown in Figure A34:

OAT:	80° F
Pressure Altitude:	6,000 feet
Rate of Climb:	450 ft/min

Fuel flow is found using the same procedure with the fuel flow line.

To determine time to climb, fuel to climb, or distance to climb, the chart must be used twice. Enter with the initial OAT, go up to the initial pressure altitude, over to the appropriate line, and straight down to read the value. Repeat this process with the final conditions. The difference between the two values will be the time, fuel, or distance expected to be seen in the climb. For the example shown in Figure A35:

Start OAT:	80° F
Start Pressure Altitude:	6,000 feet
Start Time:	16 min
End OAT:	66° F
End Pressure Altitude:	10,000 feet
End Time:	27 min
Time to Climb:	11 min

Fuel to climb and distance to climb are found using the same procedure with the appropriate line.

There is a substantial difference between the variation of time, fuel, and distance to climb and the variation of rate of climb with non-standard conditions. Thus, these are plotted on separate charts. However, the difference in the variation of time and fuel to climb and the variation of distance to climb with non-standard conditions is small; on the order of 5 percent. To reduce the number of charts in the pilot's checklist, the time, fuel, and distance to climb are presented on the same chart in the Flight Manual inputs in Appendix B. This is consistent with the data presentation format used by some general avaiation manufacturers.

The climb data presented were based on results from N557TH. The CCFT suspects that differences may exist between the climb performance of the three aircraft. Further testing should determine if differences exist in the climb performance of the three CCFT aircraft. (R4)

DESCENT PERFORMANCE

Test Objectives:

The test objectives for descent performance were:

1. Determine the best no wind glide ratio with throttle idle.

2. Determine airspeed for best glide ratio with throttle idle.

3. Determine the minimum sink rate with throttle idle.

4. Determine airspeed for minimum sink rate with throttle idle.

5. Determine time to descend, distance to descend, and fuel to descend at the best glide ratio airspeed as a function of altitude.

6. Determine time to descend, distance to descend, and fuel to descend at maximum structural cruising speed (V_{NO} - top of green arc on airspeed indicator) as a function of altitude.

7. Create charts for Flight Manual descent data.

Test Procedures:

Descent data were collected using the sawtooth descent FTT (Reference 3). Idle power constant airspeed descents were conducted at 50, 60, 65, 70, 80, and 90 KIAS. Descents were also flown at 107 KIAS and 2250 RPM to simulate enroute descents. For each test point, two descents were flown on opposite headings perpendicular to the wind. Times were recorded every 100 feet of pressure altitude using the time function of the Hewlett Packard 48SX calculator. Descent data were reduced using the methods described in Appendix D.

Test Results:

Descents were analyzed by considering the aircraft as a glider, i.e. counting any windmilling drag from the propeller against the airframe, and finding a drag polar which would represent the descent performance. This drag polar was determined by fitting a straight line to values of the drag coefficient plotted against the square of the lift coefficient, as was done for cruise data. This curve fit is shown in Figure A40. The resulting drag polar is shown in Figure A41. For reference, these figures also show the cruise drag polar. The idle descent drag polar is unusual in that it is less than the cruise flight drag polar. Generally a windmilling drag polar is greater than the cruise drag polar due to the additional drag from the windmilling propeller. However, in this case it was suspected that the reduction in separation drag over the cockpit rear

window from the reduced slipstream velocity was larger than any increase in drag arising from the windmilling propeller. The fact that both drag polars have the same parasite drag coefficient was suspected to be strictly coincidental. Aircraft without a rear window like the Cessna 150, and thus without the separation drag, would see a different relationship between the cruise and idle descent drag polars.

The idle descent drag polar was

$$C_D = 0.0427 + 0.0477C_L^2$$

Using this drag polar, the descent performance for the aircraft was analyzed. Figure A42 shows the penetration chart (L/D vs. Indicated Airspeed). The maximum glide ratio was 11 at 50 KIAS. At the Flight Manual recommended glide speed of 65 KIAS, the glide ratio was 10.5, or a reduction of 5 percent. Either airspeed should be operationally acceptable. The Flight Manual speed has the advantage of being the same as the climb speed, and thus one less airspeed for the pilot to remember.

Figure A43 shows the polar chart (Rate of Descent vs Indicated Airspeed). Figure A44 shows the same data presented against true airspeed. These charts show a small variation in rate of descent with altitude. The minimum sink rate at sea level is 530 ft/min at 50 KIAS. Theory states that the minimum sink rate should occur at a slower airspeed than the best glide ratio. The true minimum sink rate probably occurs at a slower speed than 50 KIAS, and possibly the minimum sink rate is at just above the stall speed, and not at the minimum of the power required curve. For the airspeeds tested, the minimum sink rate occured at 50 KIAS.

Figure A40 through Figure A44 also show values for a penetration descent at V_{NO} (107 KIAS) and 2250 RPM. The tachometer was placarded to avoid descending in the range of 1850 - 2250 RPM. Idle RPM would be below this range, and the descent rate would be too high for a normal penetration descent. Flying at full throttle and 107 KIAS would overspeed the engine at high altitudes and have too slow of a descent rate. An RPM of 2250 was chosen as being easy to remember, and the top end of the caution range. A C_L of 0.28 and a C_D of 0.022 were used to predict descent performance for this flight condition, as shown by the two labeled data points on Figure A41. The resulting descent rate of 900 ft/min is probably still too high for a penetration descent in operational conditions. Investigate descents at 107 KIAS and RPM greater than 2250 to find the optimum throttle setting for a penetration descent. (R5)

Fuel burn was not measured during the descents because of the short duration of the descents. By observing the fluctuating fuel flow indications, the test team estimated a fuel flow of 1.5 gal/hr for idle descents, and a fuel flow of 5.5 gal/hr for descents at 107 KIAS and 2250 RPM.

Figure A45 through Figure A47 show the descent performance at idle power and 65 KIAS for non-standard conditions. Figure A48 through Figure A50 show the same data for descents at 107 KIAS and 2250 RPM. These charts are also submitted for Flight Manual inputs in Appendix B. These charts are used in the same manner as the corresponding climb charts. In this case, the variation of distance with non-standard conditions was sufficiently different from that of time and fuel that distance is presented as a separate chart.

TAKEOFF PERFORMANCE

Test Objectives:

The test objectives for takeoff performance were:

1. Determine takeoff ground roll using the Flight Manual takeoff procedure.

2. Create charts for Flight Manual takeoff data.

Test Procedures:

Takeoff data were collected using the Flight Manual procedure. This procedure consisted of

> **Maintain directional control by use of nosewheel steering. Hold the elevator slightly aft of neutral to keep weight off the nose gear and hold aileron into the wind. At 50 KIAS, raise the nose smoothly to takeoff attitude. Maintain this attitude and allow the aircraft to fly off the ground which will occur between 50 and 60 knots.** (Reference 1)

All takeoffs were done with flaps fully retracted. The fuel mixture was leaned at fields above 5000 feet elevation. Below 5000 feet elevation, takeoffs were done with the mixture at full rich.

Pressure altitude, outside air temperature, fuel used, wind direction and wind velocity were recorded prior to takeoff. The time from brake release to liftoff and the liftoff airspeed were recorded during the takeoff. If available, runway lights were used to estimate the takeoff distance. The data were reduced and corrected to a common liftoff speed to determine takeoff distance. These distances were standardized to produce a chart for predicting takeoff distance by the methods shown in Appendix D.

Test Results:

Twenty four takeoffs were accomplished at pressure altitudes ranging from 1490 to 6780 feet. The Flight Manual procedure specifies a rotation airspeed, not a liftoff airspeed. The liftoff airspeeds varied from 52 to 65 KIAS, with an average of 57 KIAS. All takeoff data were standardized to a liftoff airspeed of 57 KIAS, zero wind, standard weight of 1760 pounds, and sea level density. These results are shown in Figure A51. This chart was also included in the Flight Manual inputs in Appendix B.

The mean ground roll distance was 1000 feet at a mean liftoff airspeed of 57 KIAS. The 95 percent confidence interval for ground roll distance (one-tailed test; shorter ground rolls are not an operational concern) was bounded at 1165 feet. The 99 percent confidence interval for ground roll distance was bounded at 1234 feet. The 95 percent confidence interval (two-tailed test) for liftoff airspeed was bounded at 51 KIAS and 63 KIAS.

Using the methods shown in Appendix D, the mean ground roll distance was expanded for non-standard conditions as shown in Figure A52. This chart is of the same form used by several general aviation manufacturers. To use this chart, enter at the field OAT. Go up to the current field pressure altitude. Go across to the Weight Reference Line. From here, follow the guidelines down until reaching the vertical line for the takeoff weight. Go across to the Wind Reference Line. Follow the guidelines to the wind component down the runway (down for headwinds, up for tailwinds). Go across to the right side to read the mean takeoff ground roll in feet. For the example shown:

OAT:	80° F
Pressure Altitude:	6,500 feet
Weight:	1600 lbs
Headwind:	10 knots
Ground Roll:	1170 feet

Figure A53 and Figure A54 are included to show the effects of dispersion on ground roll distance. These figures show how much additional distance should be added to find the distance at the limit of the 95 percent and 99 percent confidence intervals. Only the effects of weight and density altitude are shown. A headwind will always shorten the takeoff roll, and takeoffs should not be attempted in anything above a very small tailwind. To use these charts, enter with the takeoff weight, go up to the appropriate density altitude, and to the left to read the dispersion distance. Add this distance to the mean takeoff ground roll to get the maximum expected ground roll.

Note that normally Figure A53 and Figure A54 would not be needed by the operational pilot. Additional runway length allowed for stopping after an engine failure on the runway will normally greatly exceed the additional distance from dispersion.

CONCLUSIONS AND RECOMMENDATIONS

Performance data were collected on the USAF Academy Cadet Competition Flying Team (CCFT) Cessna 150 in the areas of cruise, Pitot-statics, climb, descent, and takeoff. These data were used to develop a computer model of the aircraft using the Reciprocating Engine and Propeller Modeling Program (*RPM*). This computer model was then used to create performance charts and tabulated data for the operational flight envelope for inclusion in the next update of the Flight Manual. All test objectives were met.

Cruise flight was characterized by the aircraft drag polar,

$$C_D = 0.042696 + 0.068861\ C_L^2$$

derived from flight test. Based on limited flights in two of the aircraft, drag and power required data for all three aircraft were in satisfactory agreement.

> ***1. Additional testing should be conducted to verify the validity of the drag polar for all three aircraft. (Page 4)[2]***

The fuel flow data was modeled with satisfactory agreement with the flight test data. Tabulated cruise data were created on 5x8" cards for flight planning purposes, with power settings above 75 percent flagged.

The maximum range airspeed was 65 KIAS. An airspeed of 85 KIAS gave the maximum airspeed per pound of fuel burned, with a reduction in range of 10 to 20 percent. Typical 94 FTS operational procedures of flying at maximum speed resulted in a reduction in range of 23 to 40 percent. The maximum endurance for airspeeds tested occurred at 50 KIAS, the minimum airspeed tested.

> ***2. Flight data, such as RPM, fuel flow, fuel used, indicated airspeed, true airspeed, range, and endurance should be collected on 94th FTS deployments and CCFT practice and competition flights and compared to the performance data presented in this report for further verification of these performance data. (Page 7)***

The Pitot-static position correction curve was derived from flight test using the GPS Speed Course and GPS Ground Speed methods. The flight test derived curve followed the general trend of the Flight Manual curve. At airspeeds normally seen during competition or cross country flight, the flight test derived curve was within one knot of the Flight Manual curve. At low speeds, the flight test curve is about 6 knots higher than the Flight Manual curve, resulting in higher calibrated airspeeds at Flight Manual takeoff and approach speeds. Based on good operational experience, there is no reason to change the Flight Manual takeoff and approach speeds.

The flight test derived position correction curve was considered valid for N557TH and N557AW. An acceptable position correction curve for N557SH could be found by subtracting 4 knots from the flight test derived position correction curve.

> ***3. Investigate the Pitot-static position corrections for N557SH and N557AW. (Page 9)***

Climb data were analyzed using the *RPM* model to match flight test data at several non-standard conditions. The model was then considered valid at all flight conditions. The flight test results for best angle of climb airspeed and best rate of climb airspeed were in good agreement with the Flight Manual, and do not warrant any changes to the Flight Manual airspeeds. The maximum rate of climb was 865 ft/min at sea level and 330 ft/min at 10,000 feet. The maximum angle of climb was 7.5 degrees at sea level and 2.6 degrees at 10,000 feet. Climb charts are presented for maximum rate of climb at 65 KIAS and for cruise climb at 80 KIAS. The climb data presented were based on results from N557TH. The CCFT suspects that differences may exist between the climb performance of the three aircraft.

> ***4. Further testing should determine if differences exist in the climb performance of the three CCFT aircraft. (Page 12)***

[2] Page numbers in parentheses refer to the page number in the Test and Evaluation section of this report where the recommendation is made.

Descent data were analyzed by considering the aircraft as a glider, counting the windmilling drag of the propeller against the airframe. The idle descent drag polar was

$$C_D = 0.0427 + 0.0477\, C_L^2$$

which led to the curious conclusion that the idle descent drag was less than the cruise drag. This was suspected to result from the interaction between the slipstream and separation drag from the cockpit rear window.

The maximum glide ratio was 11 at 50 KIAS, and 10.5 at the Flight Manual recommended glide speed of 65 KIAS. This small difference does not warrant a change to the Flight Manual, since 65 KIAS is easier to remember as the same airspeed for best rate of climb. The minimum sink rate for the airspeeds tested was 530 ft/min at 50 KIAS.

Descent performance was also investigated for a penetration descent at 107 KIAS (V_{NO}) and 2250 RPM. At these conditions, the lift coefficient was 0.28 and the drag coefficient was 0.022. The resulting descent rate of 900 ft/min is probably still too high for a penetration descent in operational conditions.

5. Investigate descents at 107 KIAS and RPM greater than 2250 to find the optimum throttle setting for a penetration descent. (Page 13)

Takeoff data were standardized to zero wind, standard weight of 1760 pounds, and sea level density. The mean ground roll distance was 978 feet at a mean liftoff airspeed of 57 KIAS. The 95 percent confidence interval for ground roll distance was bounded at 1140 feet. The 99 percent confidence interval for ground roll distance was bounded at 1208 feet. The 95 percent confidence interval for liftoff airspeed was bounded at 51 KIAS and 63 KIAS.

The performance of the CCFT Cessna 150 was satisfactorily characterized. Further testing should address the recommendations of this report, and the results of this testing should be incorporated in the Flight Manual.

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APPENDIX A

TEST DATA

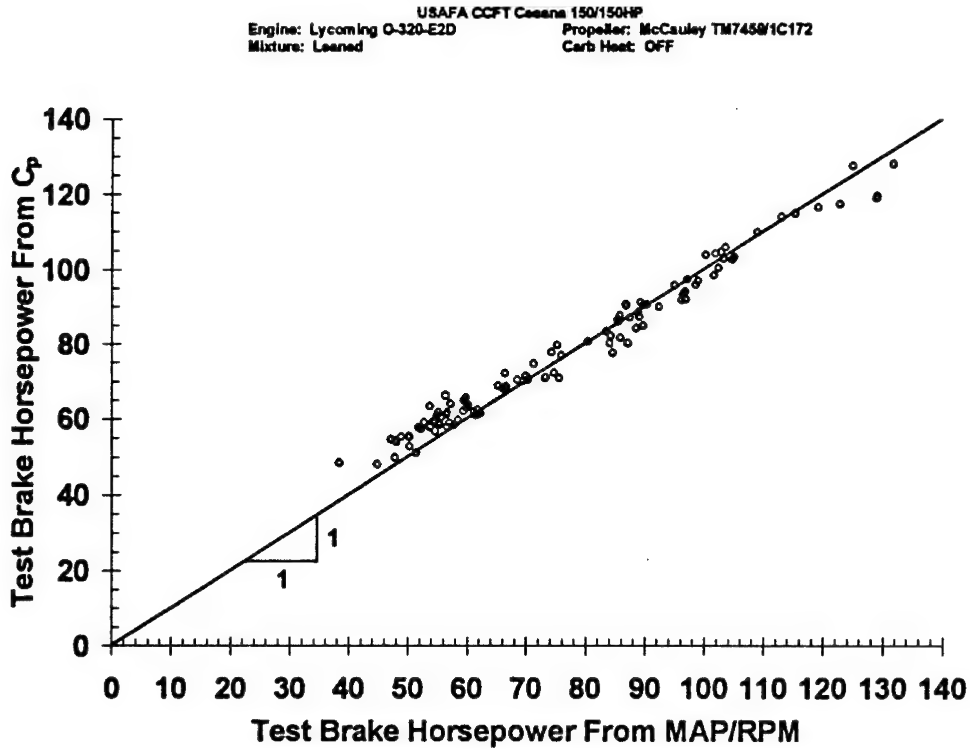

Figure A1 Engine Horsepower Determination Methods Comparison

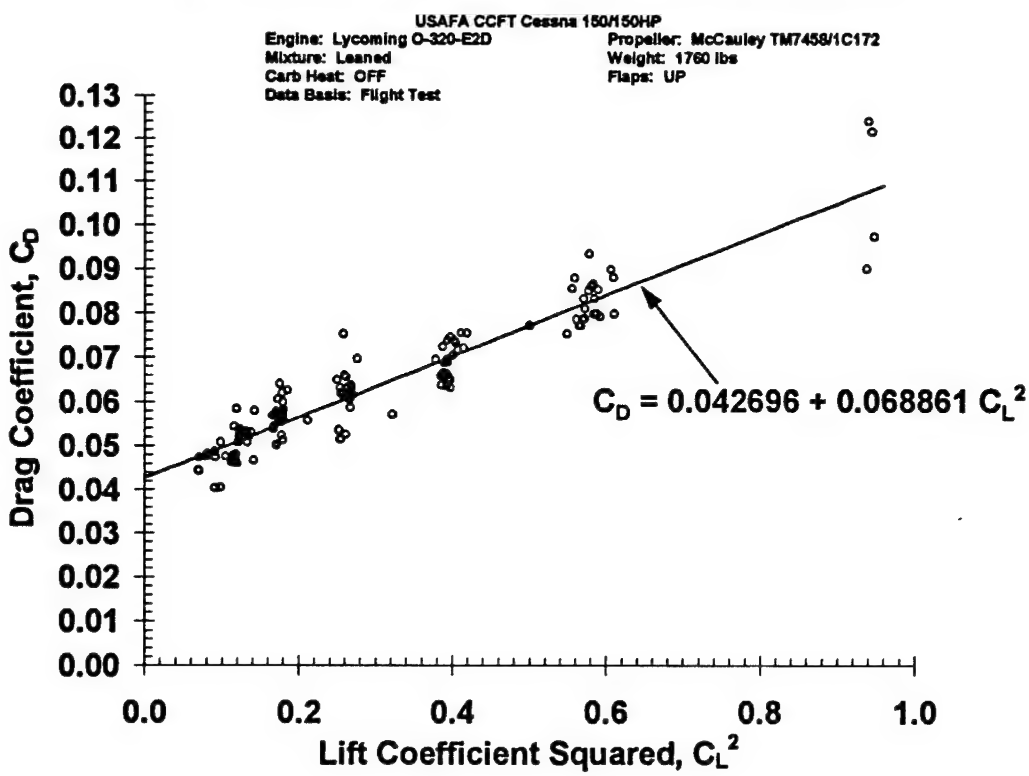

Figure A2 Drag Polar Curve Fit

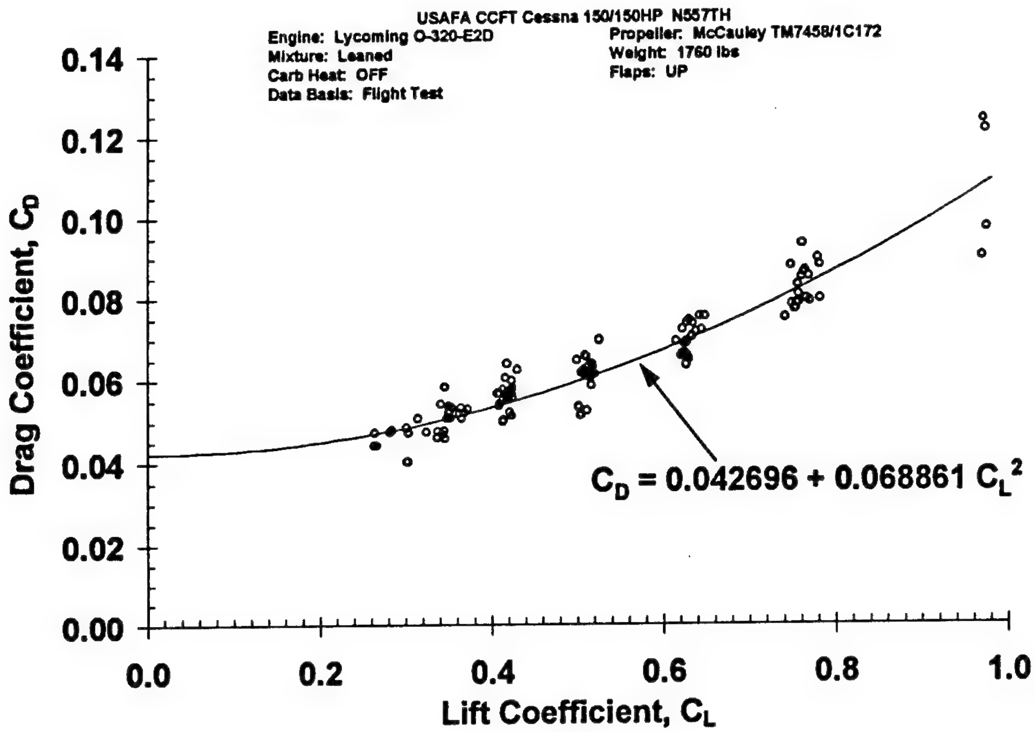

Figure A3 N557TH Drag Results Compared to Aircraft Drag Polar

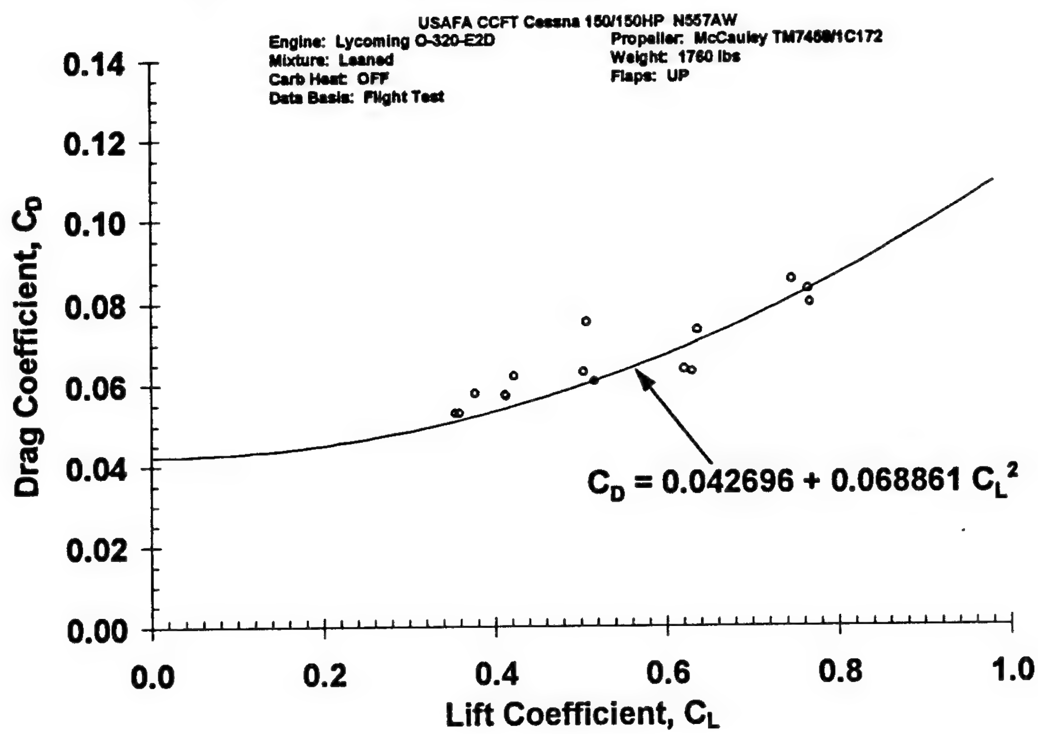

Figure A4 N557AW Drag Results Compared to Aircraft Drag Polar

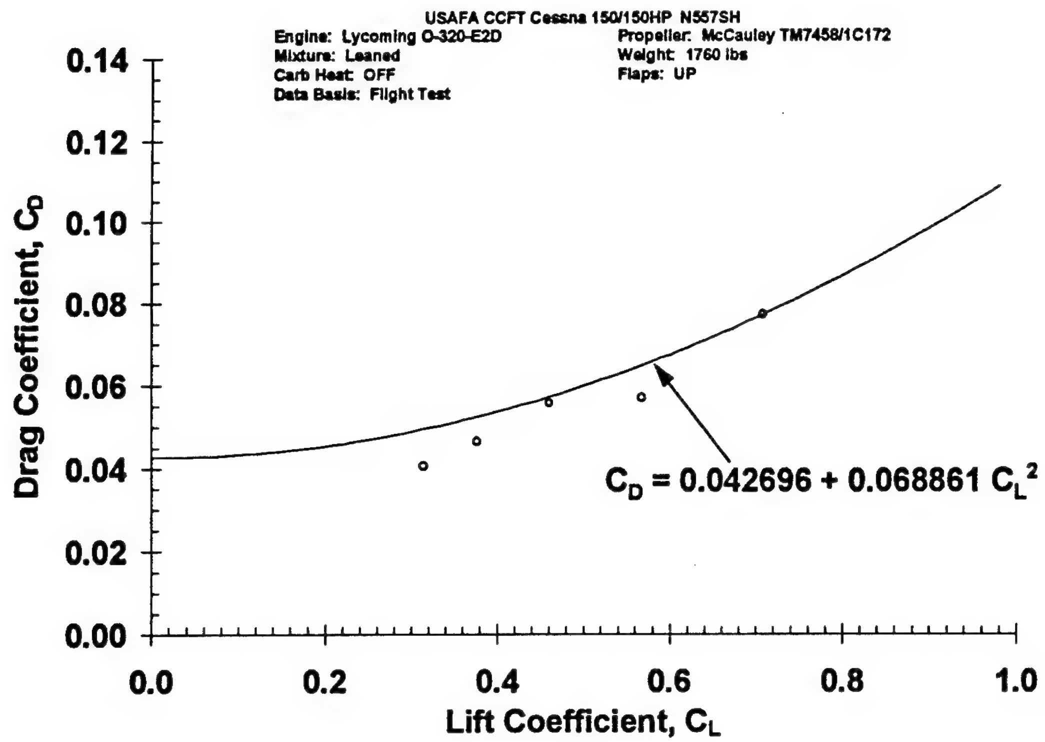

Figure A5 N557SH Drag Results Compared to Aircraft Drag Polar

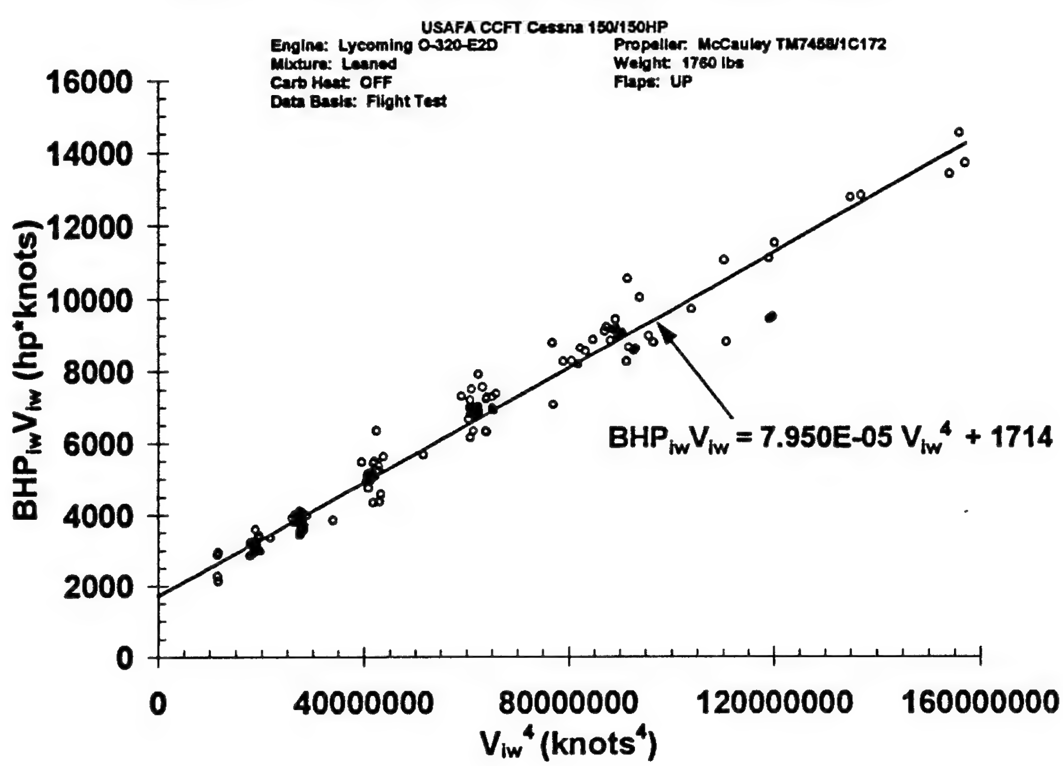

Figure A6 Brake Horsepower Required Curve Fit

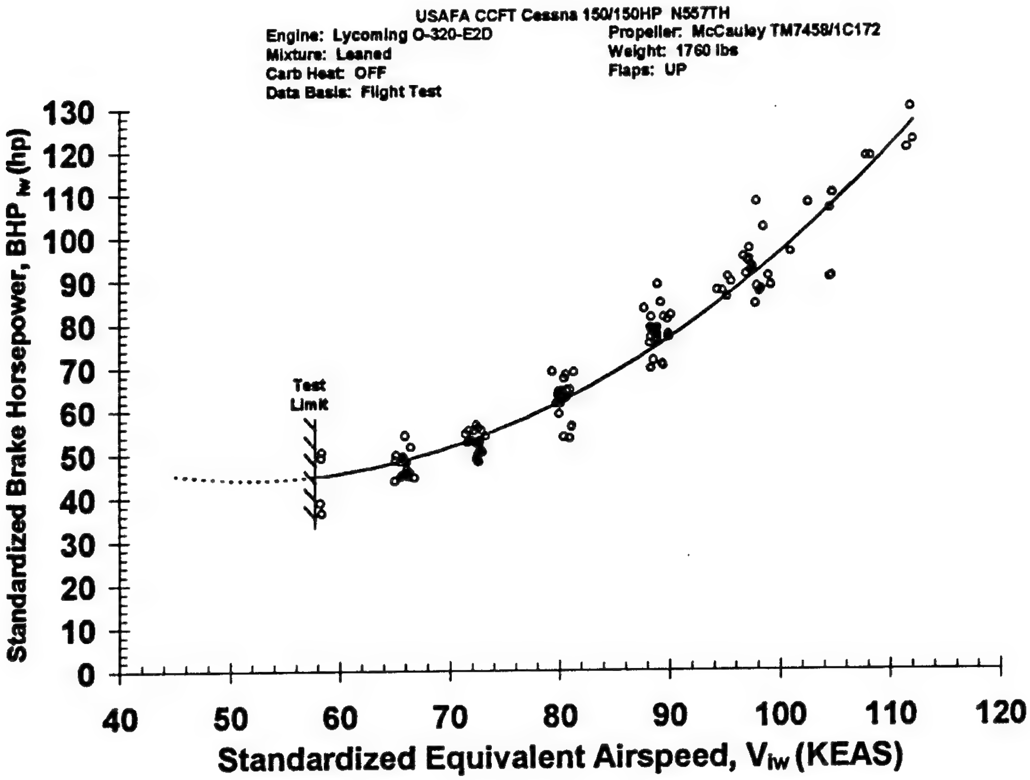

Figure A7 N557TH Brake Horsepower Required Results Compared to Aircraft Brake Horsepower Required

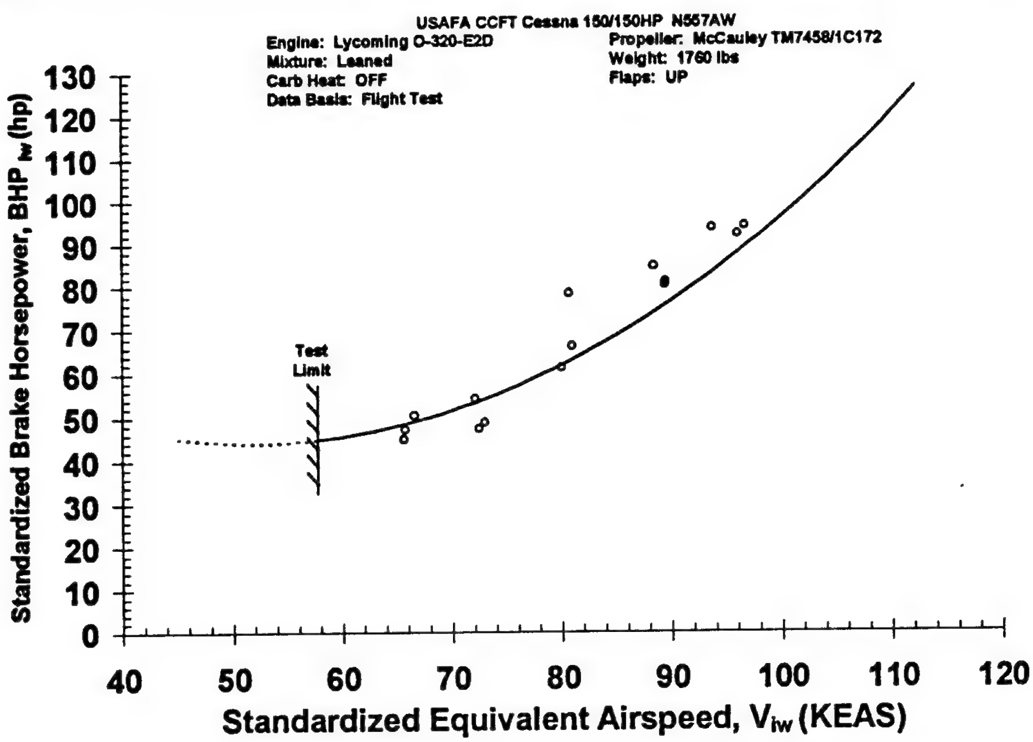

Figure A8 N557AW Brake Horsepower Required Results Compared to Aircraft Brake Horsepower Required

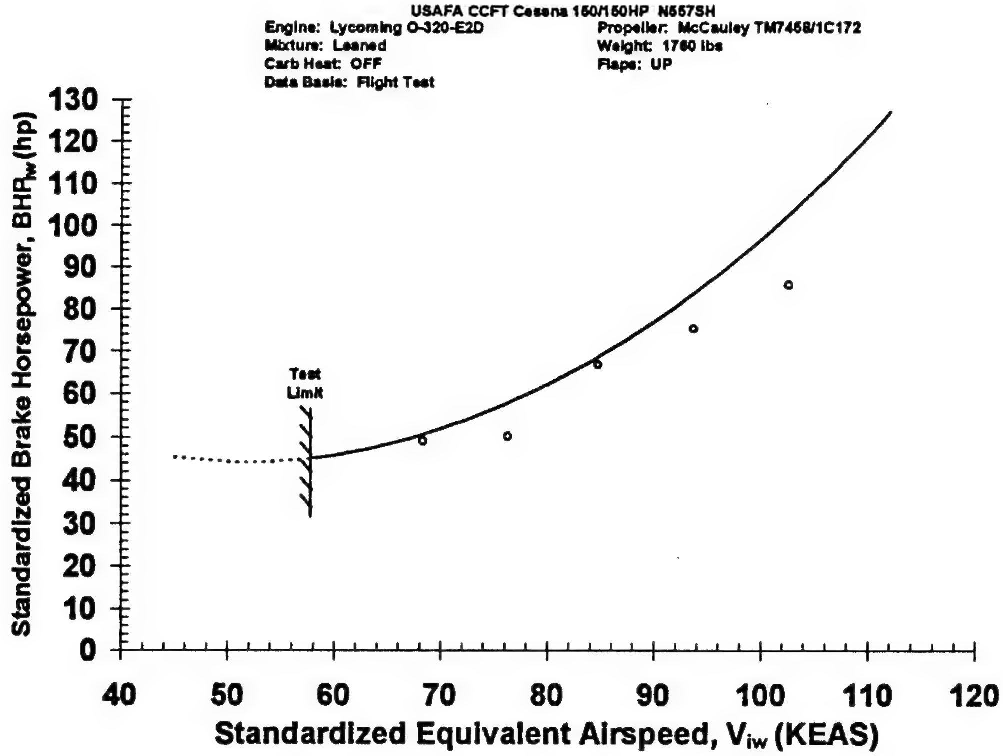

Figure A9 N557SH Brake Horsepower Required Results Compared to Aircraft Brake Horsepower Required

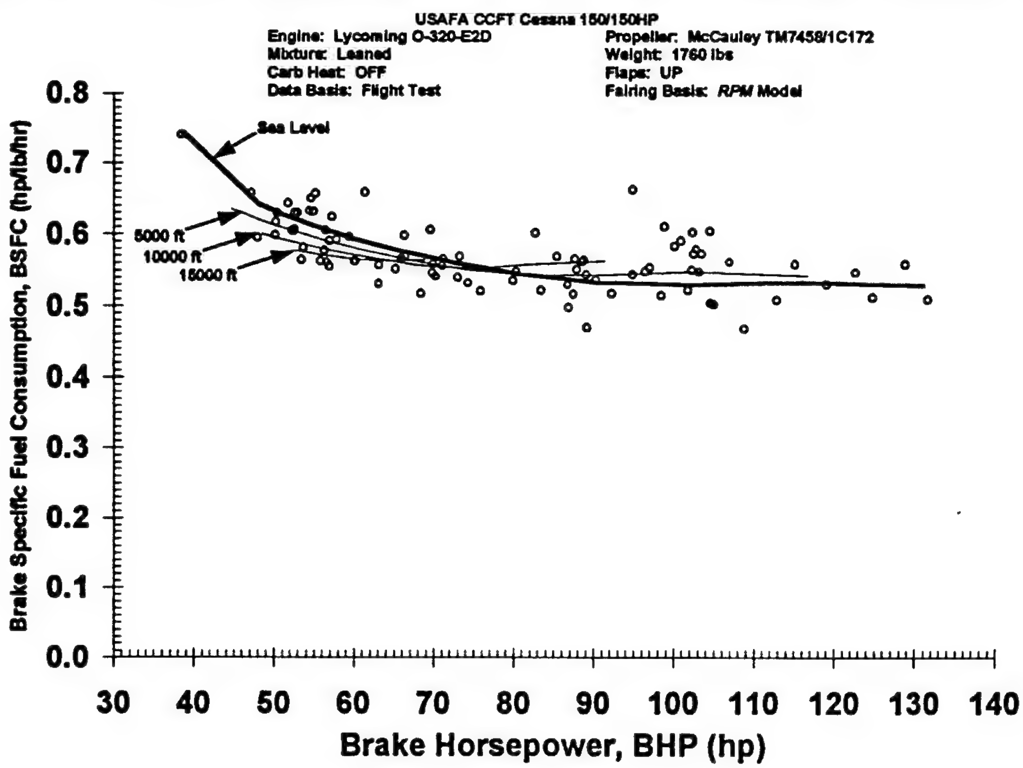

Figure A10 Brake Specific Fuel Consumption Results

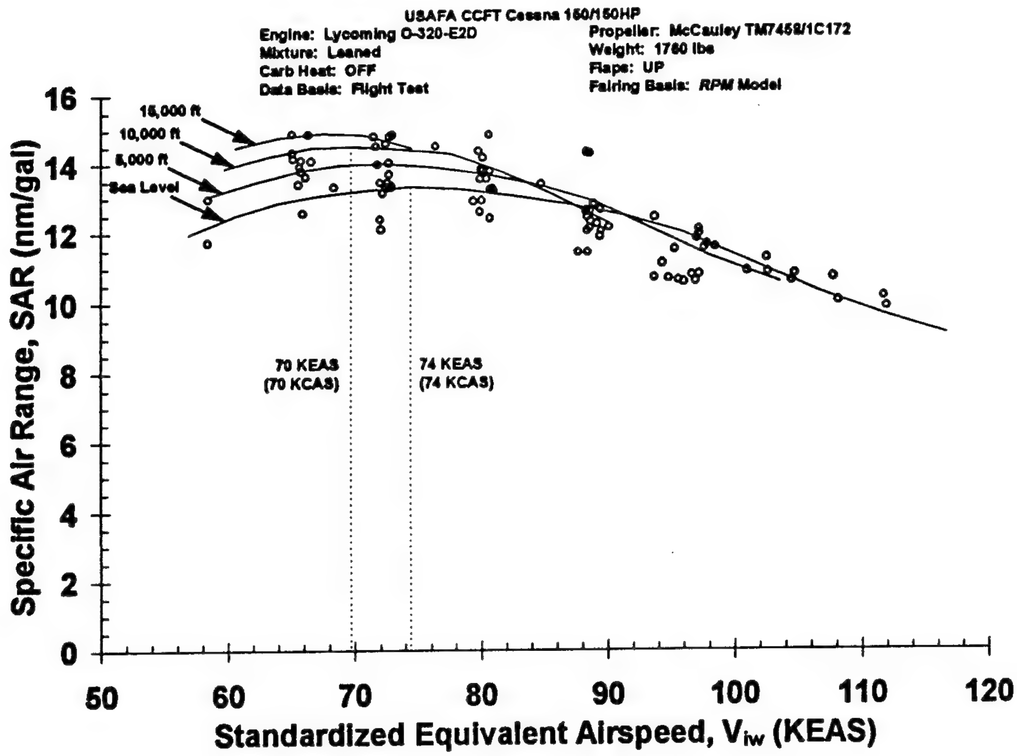

Figure A11 Specific Air Range Results

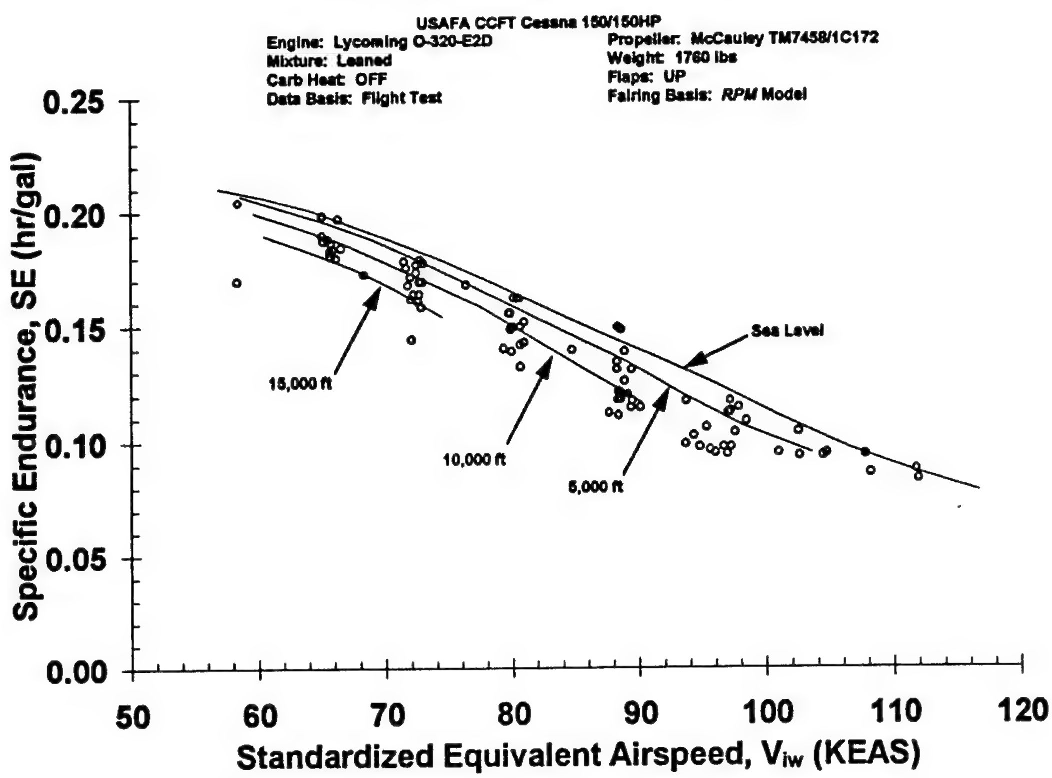

Figure A12 Specific Endurance Results

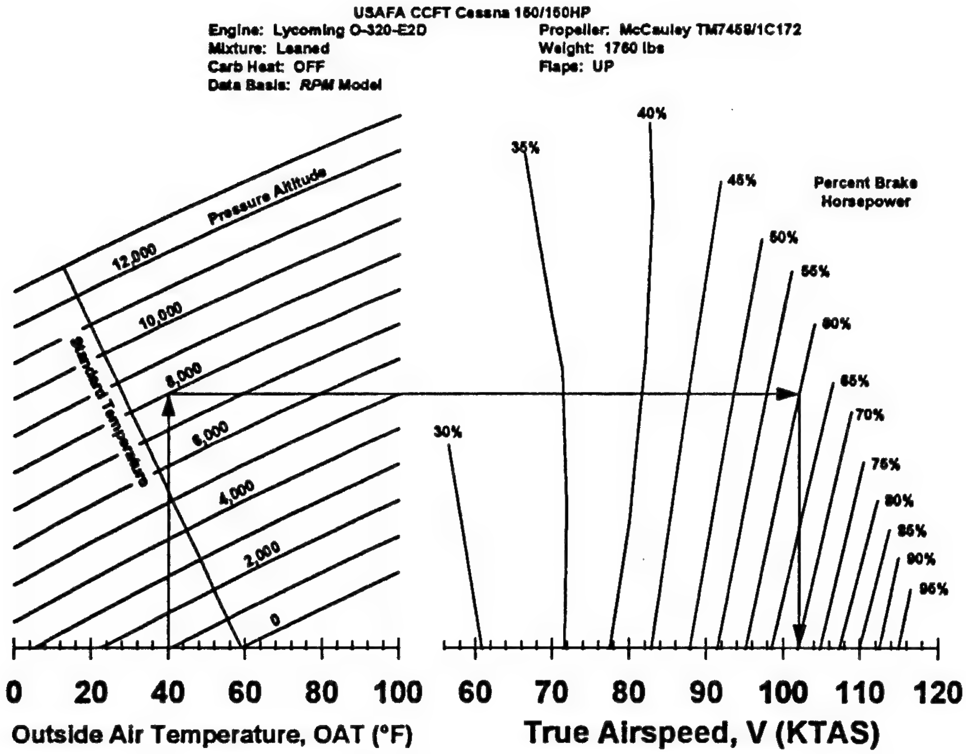

Figure A13 Cruise Airspeed Performance

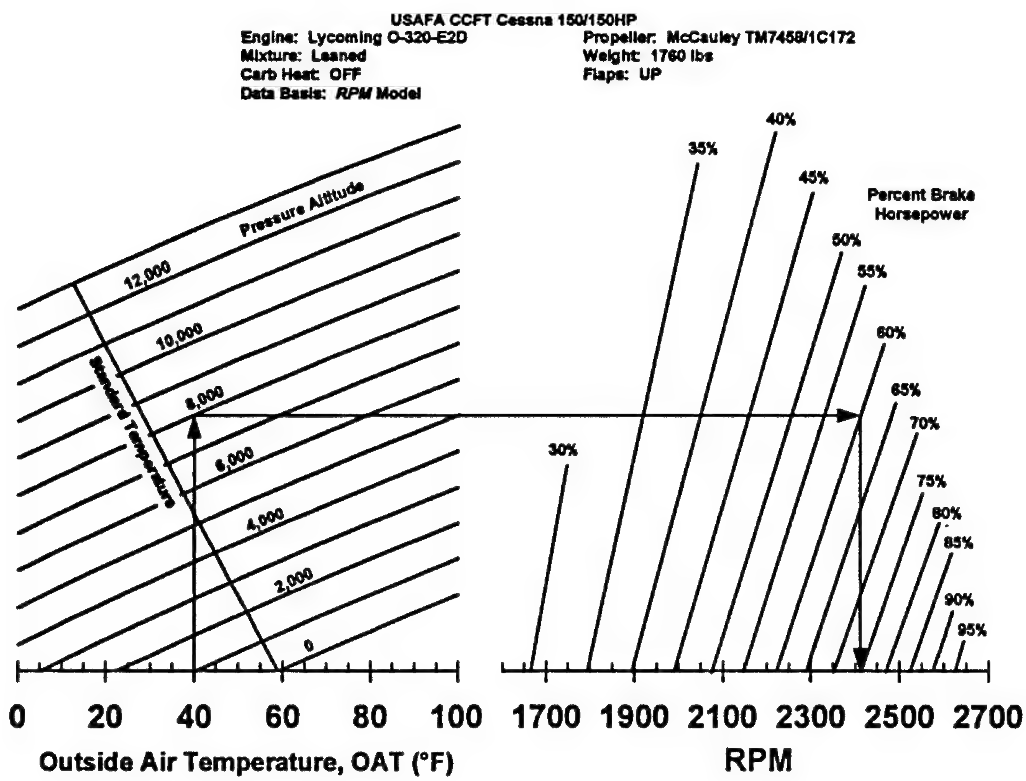

Figure A14 Cruise RPM Performance

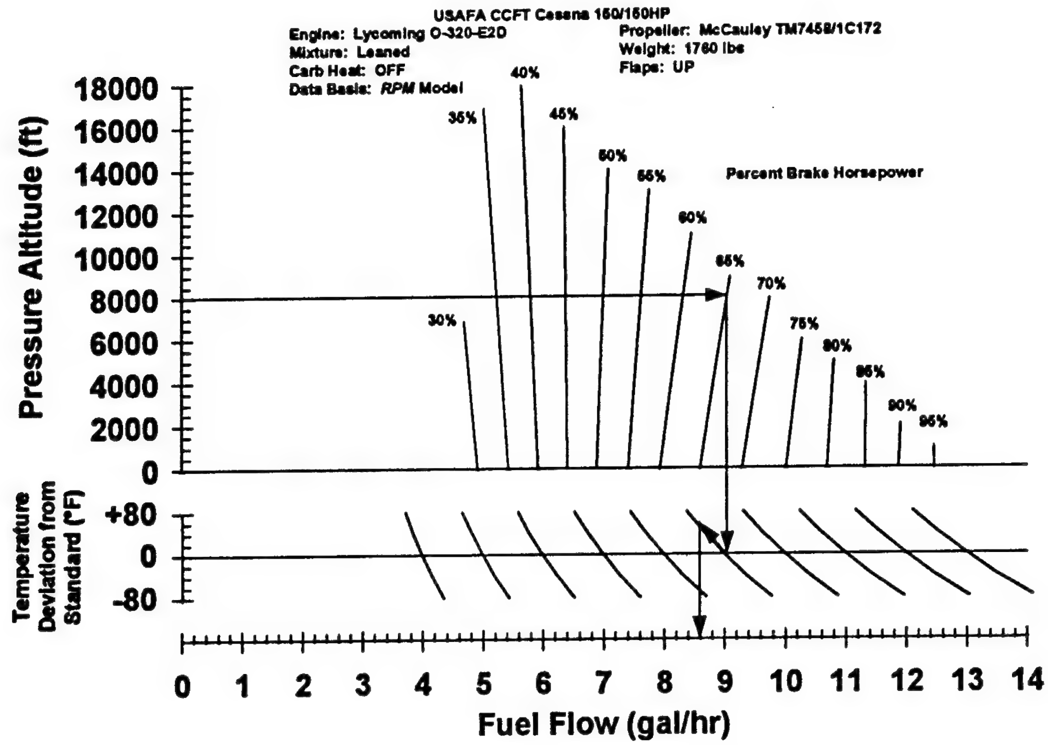

Figure A15 Cruise Fuel Flow Performance

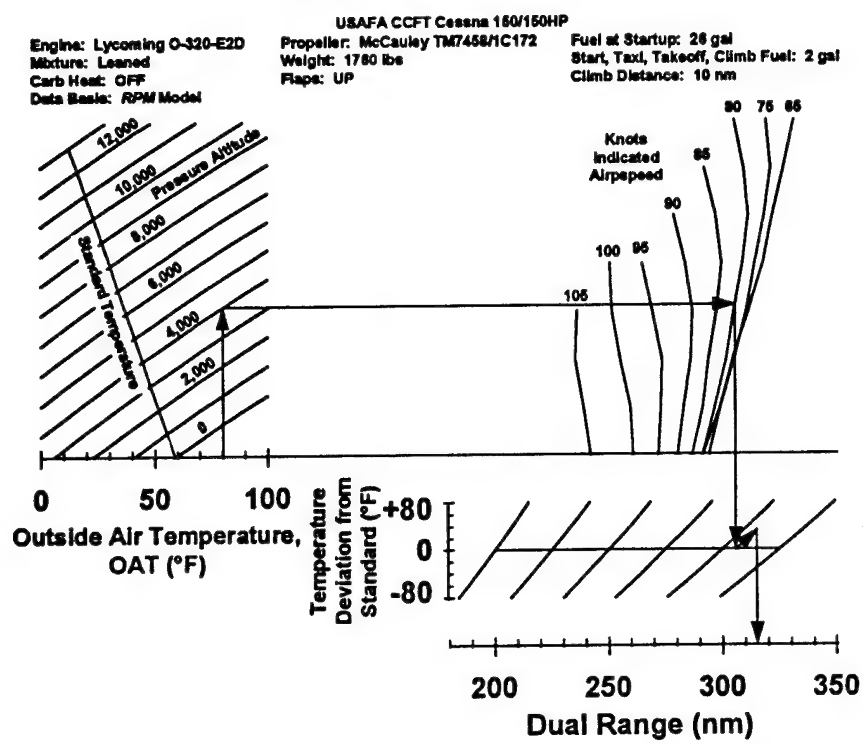

Figure A16 Dual Constant Airspeed Cruise Range Performance

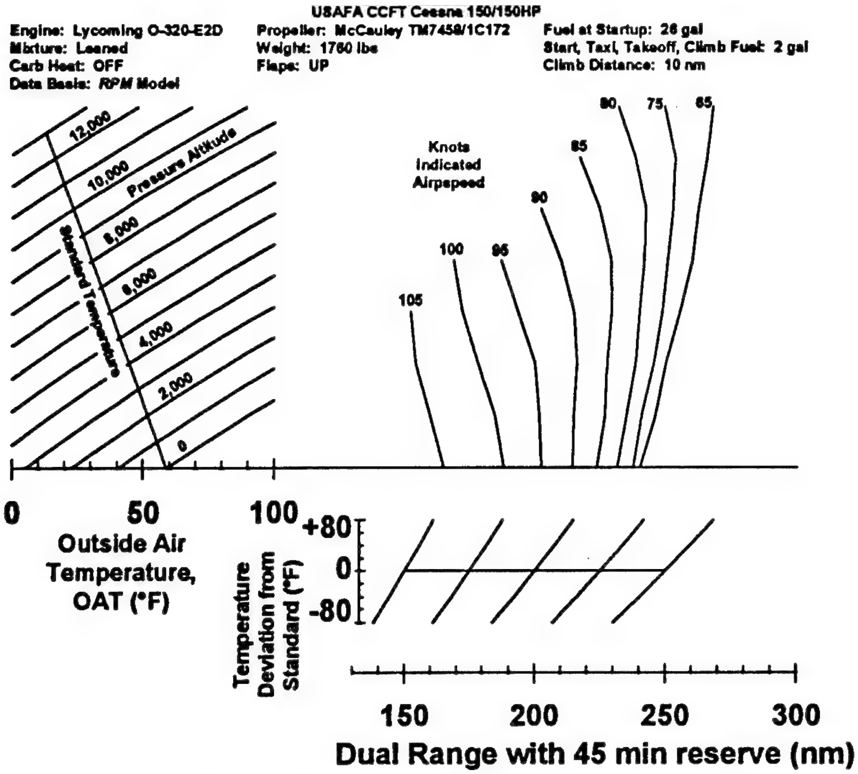

Figure A17 Dual Constant Airspeed Cruise Range Performance With 45 Minute Reserve

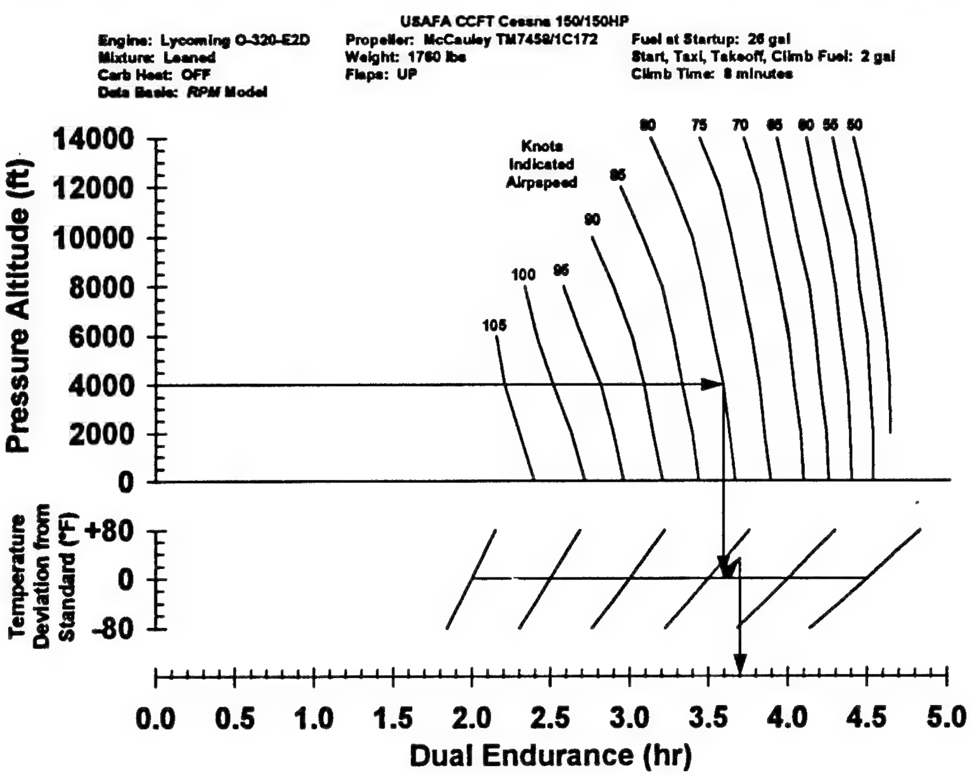

Figure A18 Dual Constant Airspeed Cruise Endurance Performance

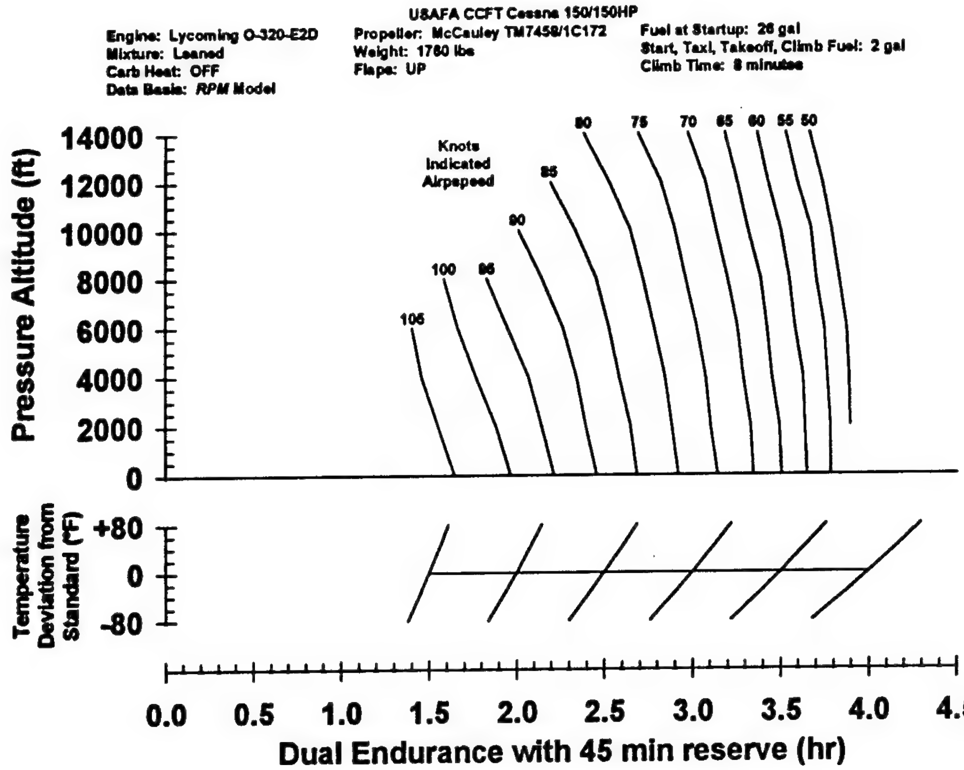

Figure A19 Dual Constant Airspeed Cruise Endurance Performance With 45 Minute Reserve

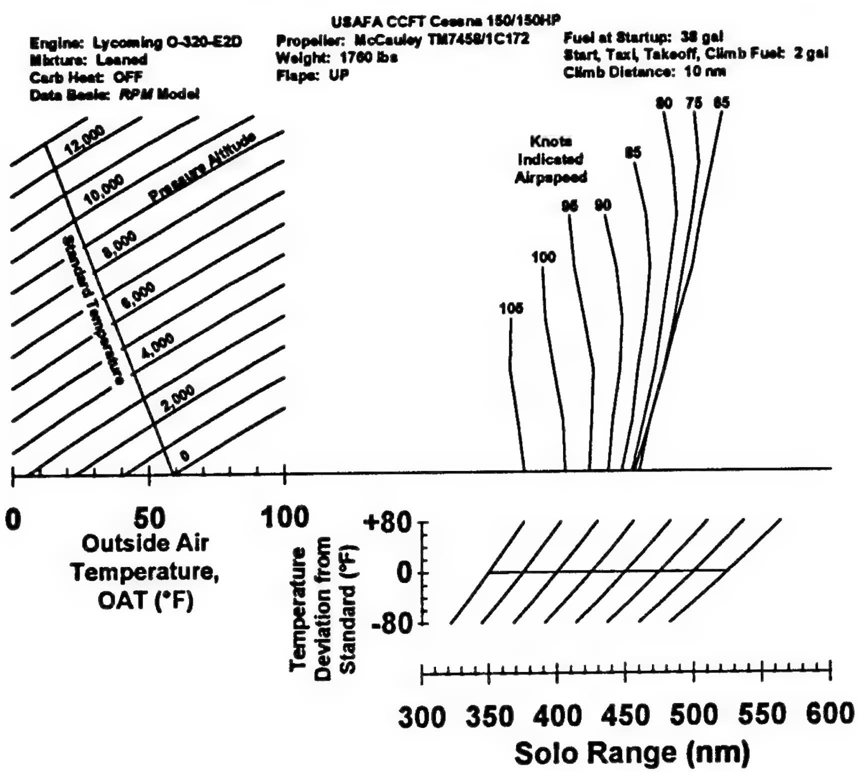

Figure A20 Solo Constant Airspeed Cruise Range Performance

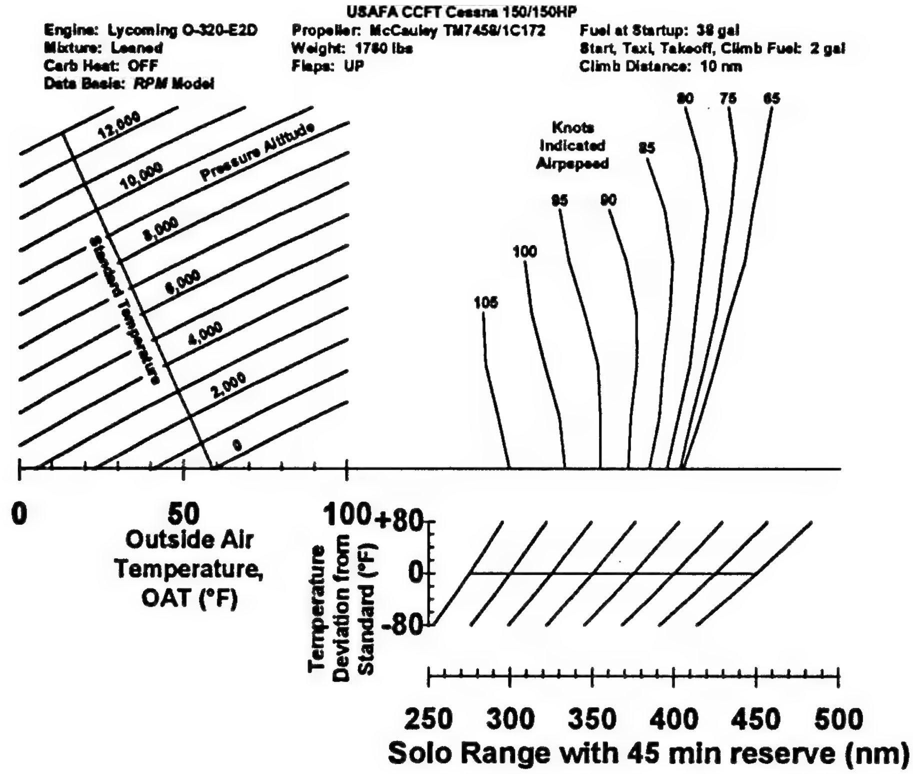

Figure A21 Solo Constant Airspeed Cruise Range Performance With 45 Minute Reserve

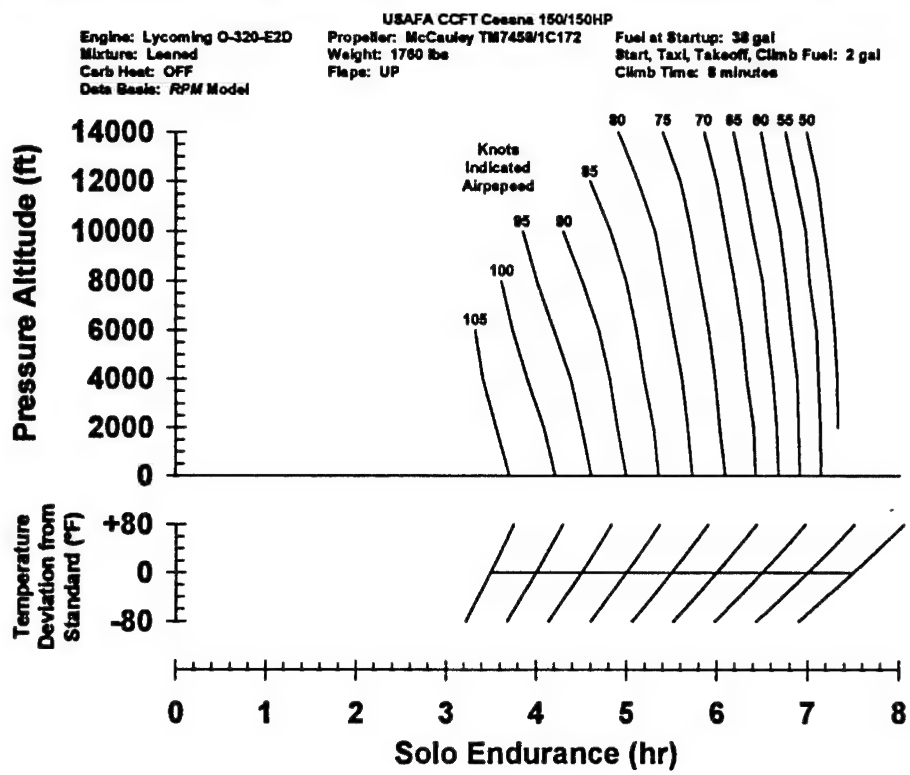

Figure A22 Solo Constant Airspeed Cruise Endurance Performance

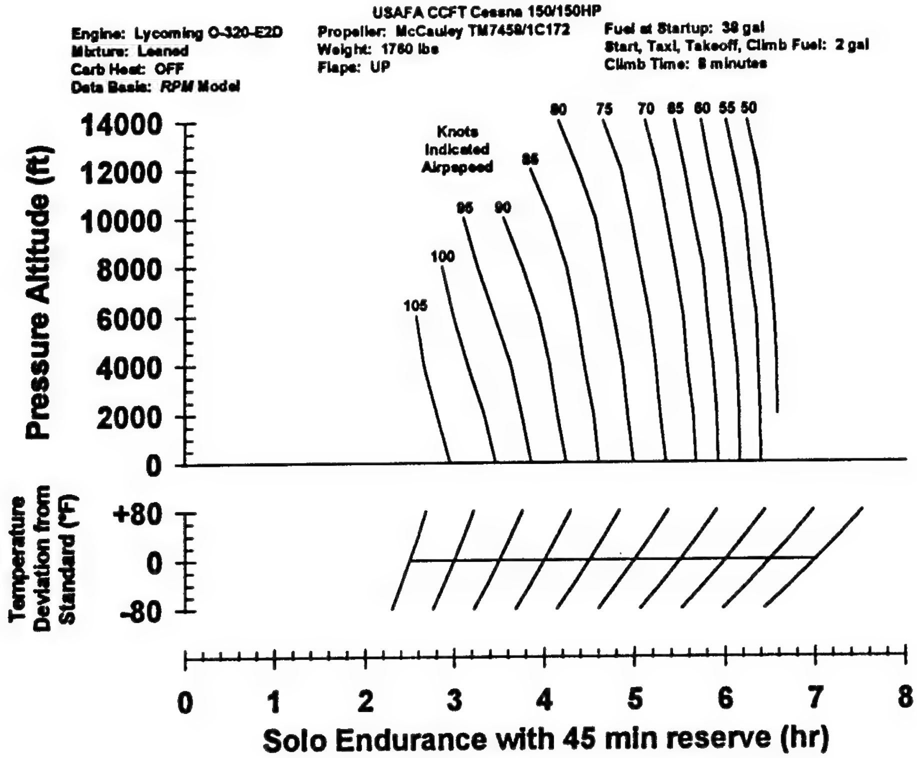

Figure A23 Solo Constant Airspeed Cruise Endurance Performance With 45 Minute Reserve

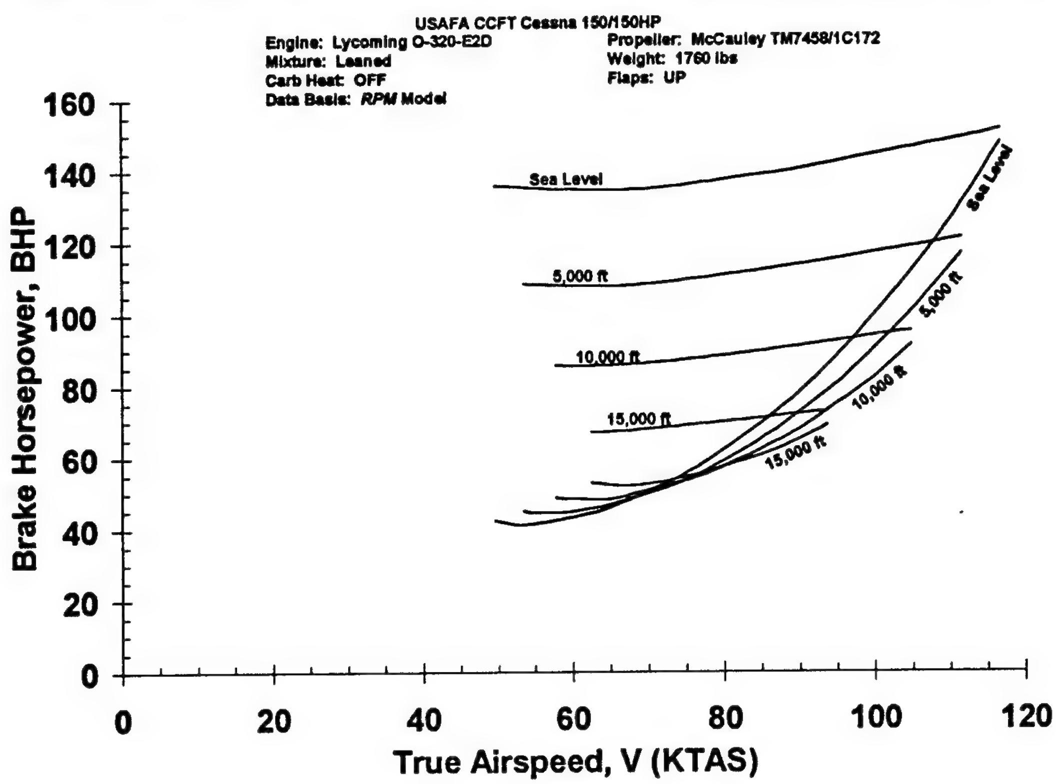

Figure A24 Aircraft Brake Horsepower Required and Available

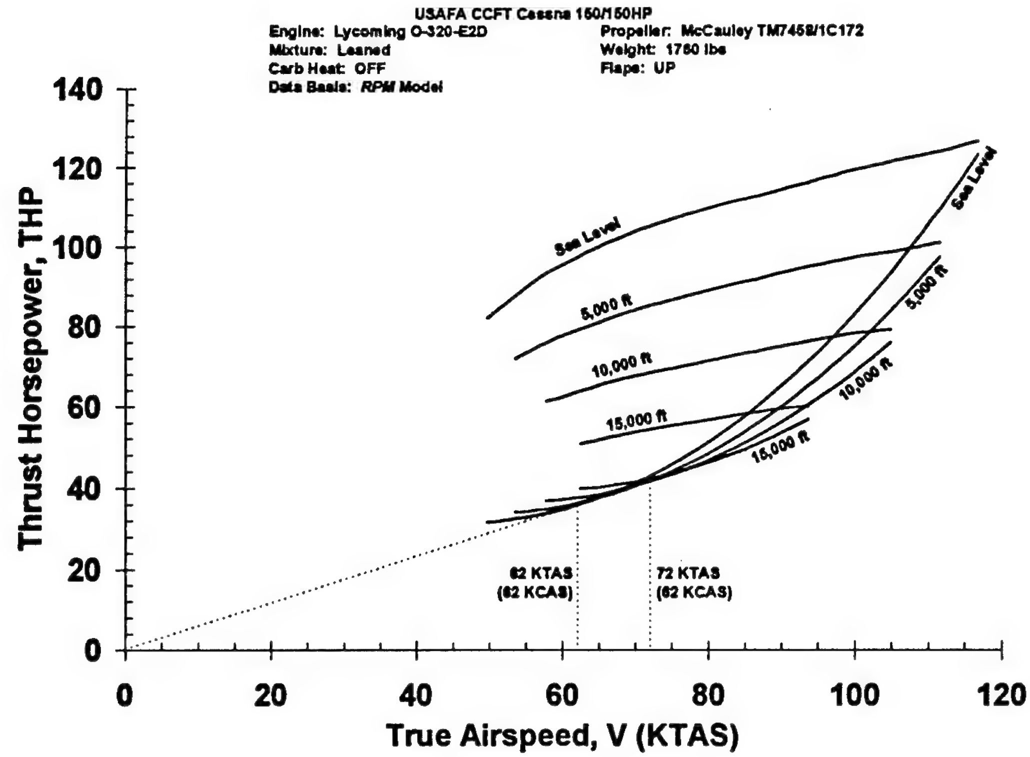

Figure A25 Aircraft Thrust Horsepower Required and Available

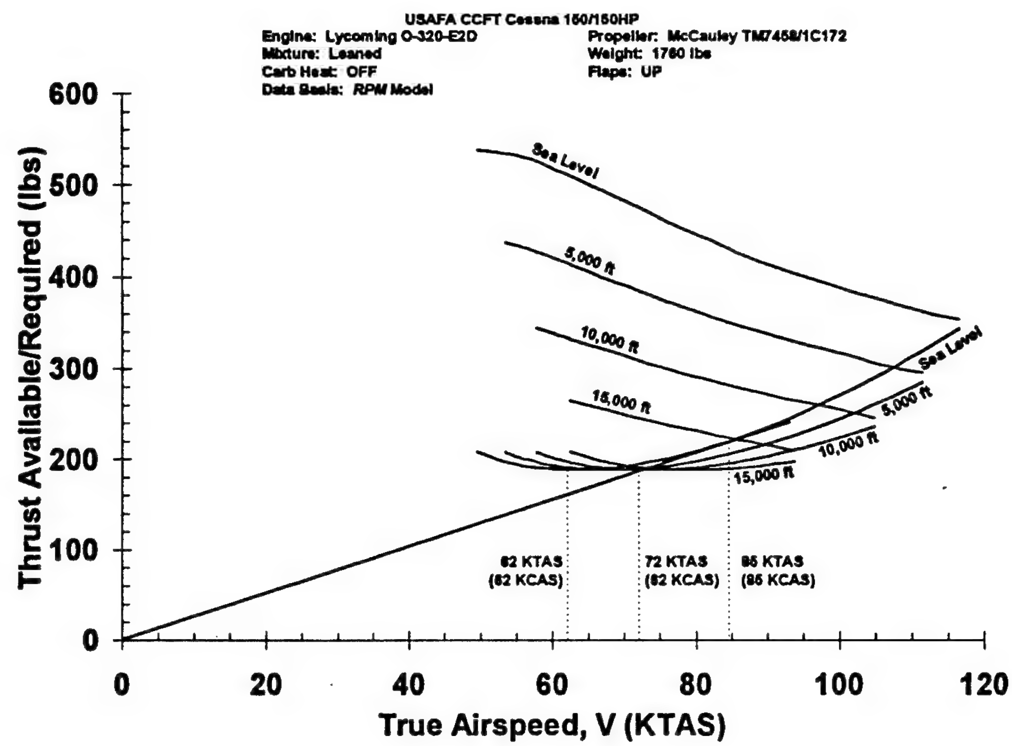

Figure A26 Aircraft Thrust Required and Available

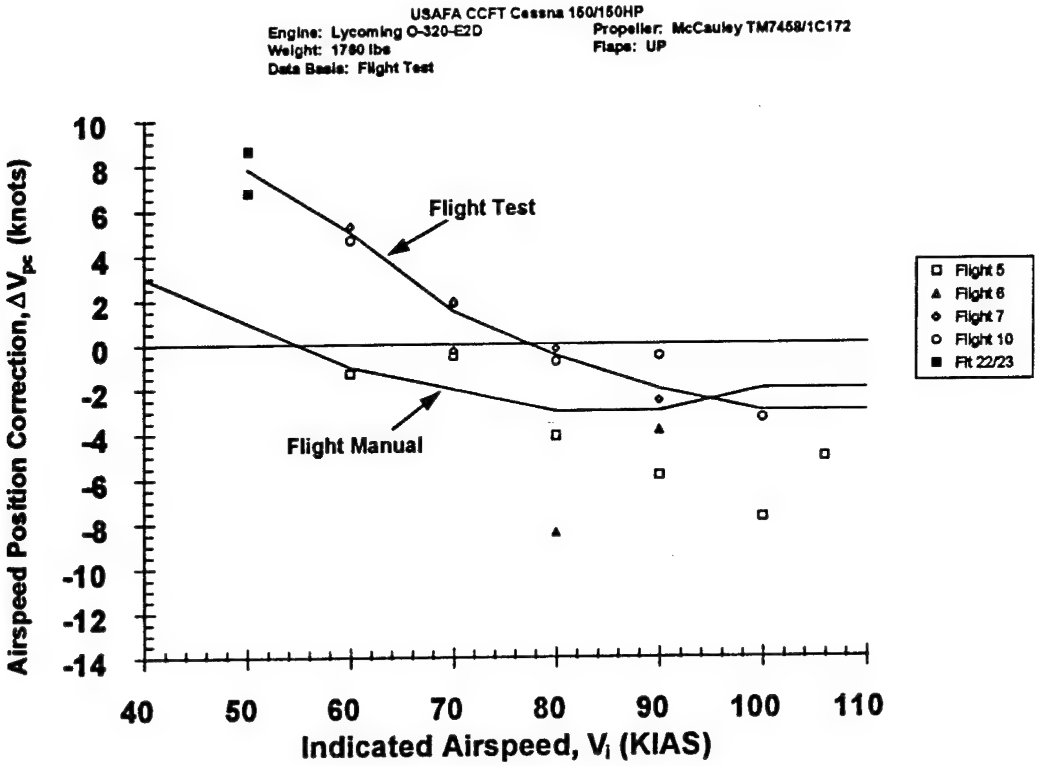

Figure A27 Airspeed Pitot-Static Position Correction

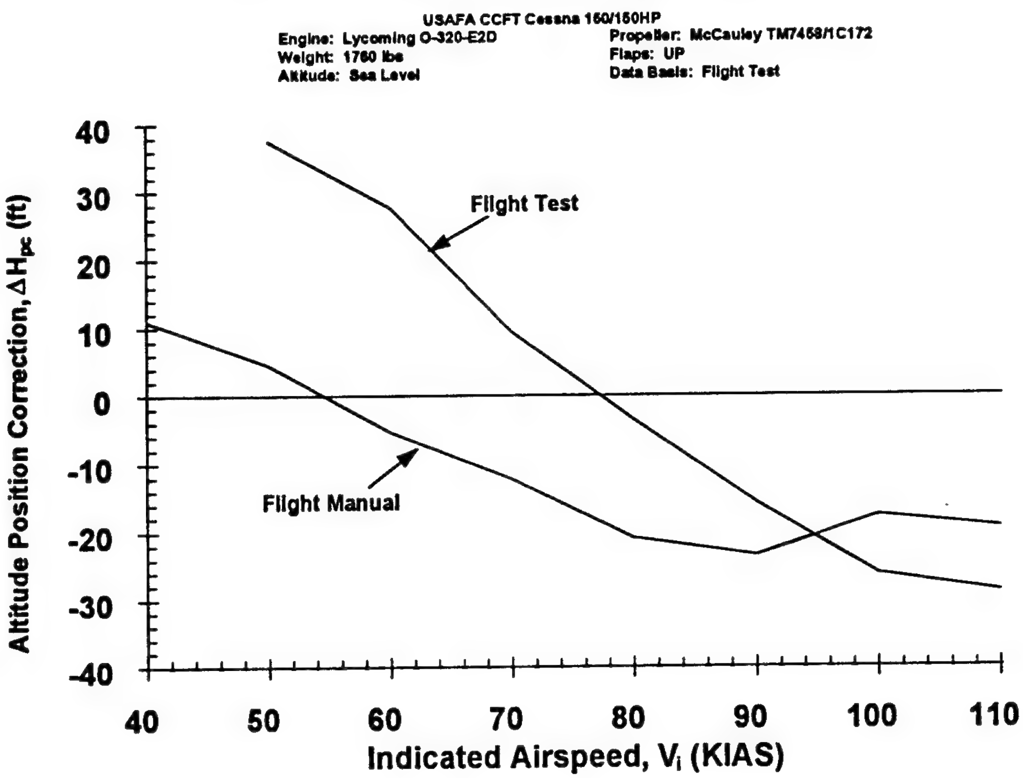

Figure A28 Altitude Pitot-Static Position Correction

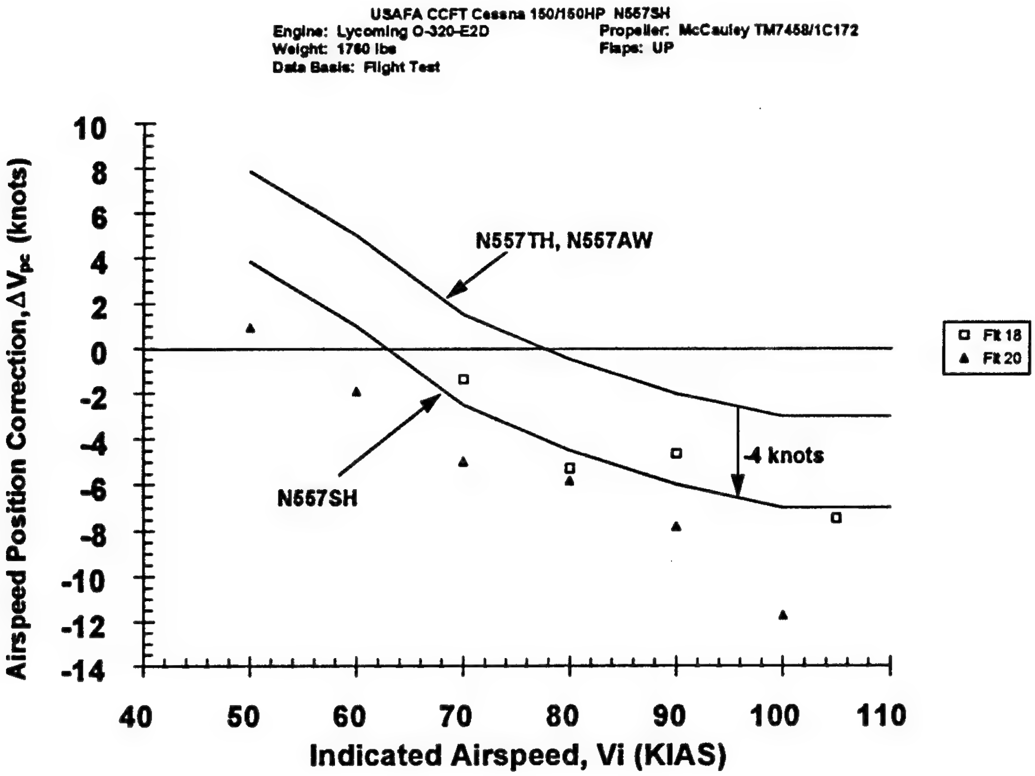

Figure A29 Airspeed Pitot-Static Position Correction, N557SH

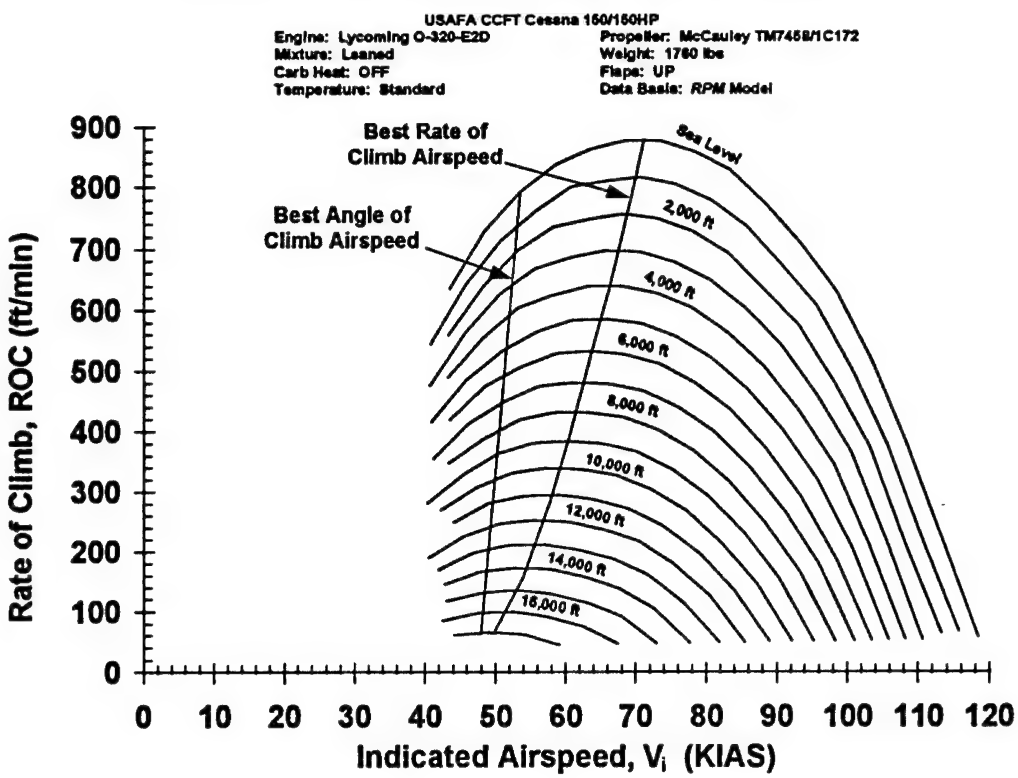

Figure A30 Standard Day Rate of Climb Performance (Indicated Airspeed)

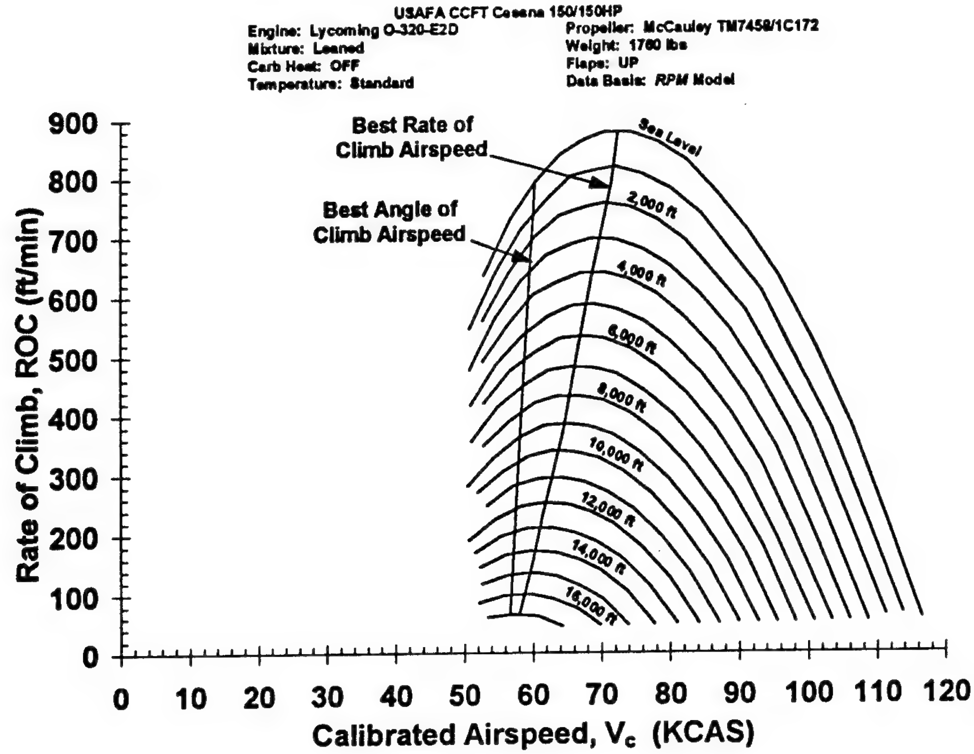

Figure A31 Standard Day Rate of Climb Performance (Calibrated Airspeed)

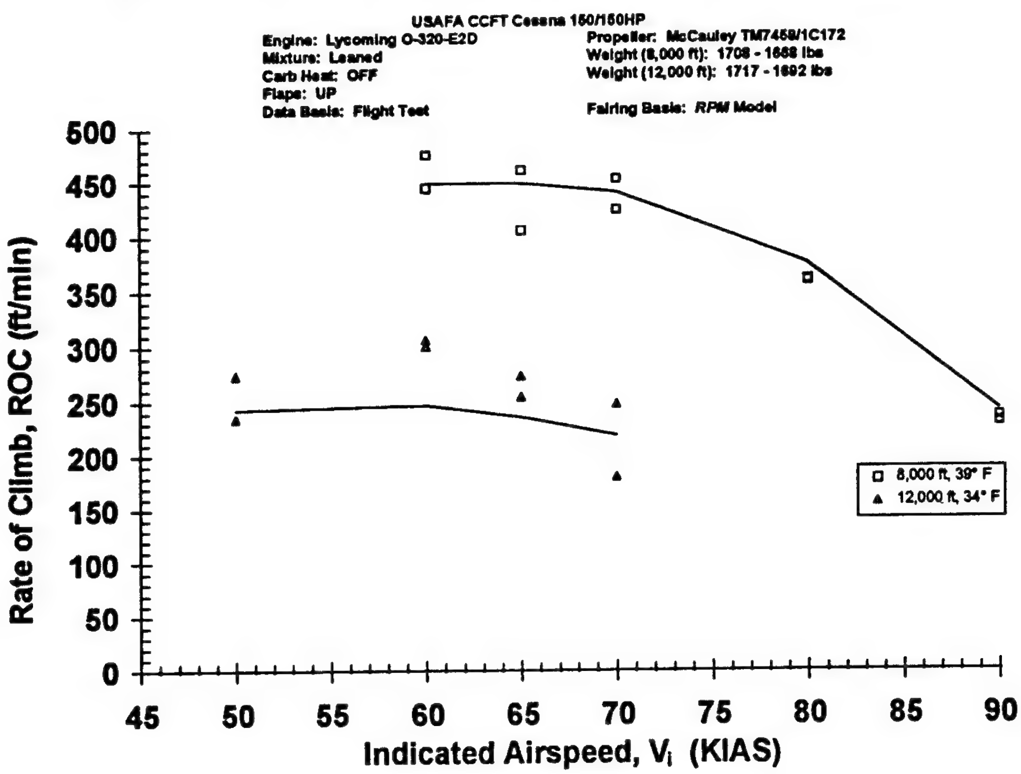

Figure A32 Test Day Rate of Climb Matching

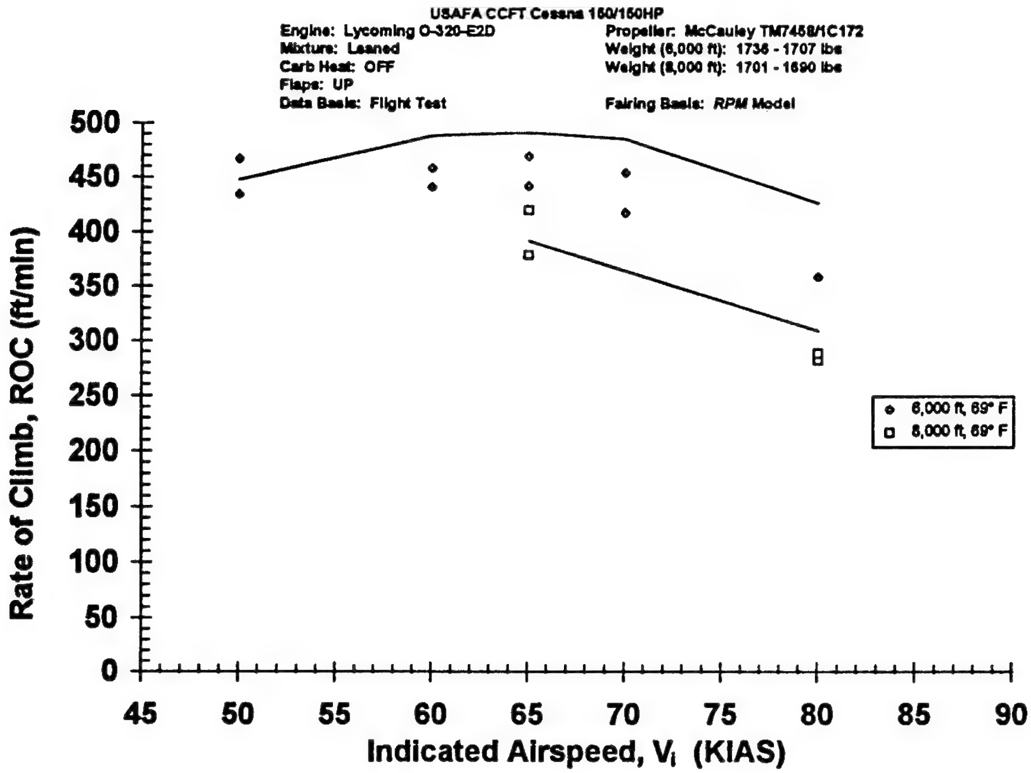

Figure A33 Test Day Rate of Climb Matching

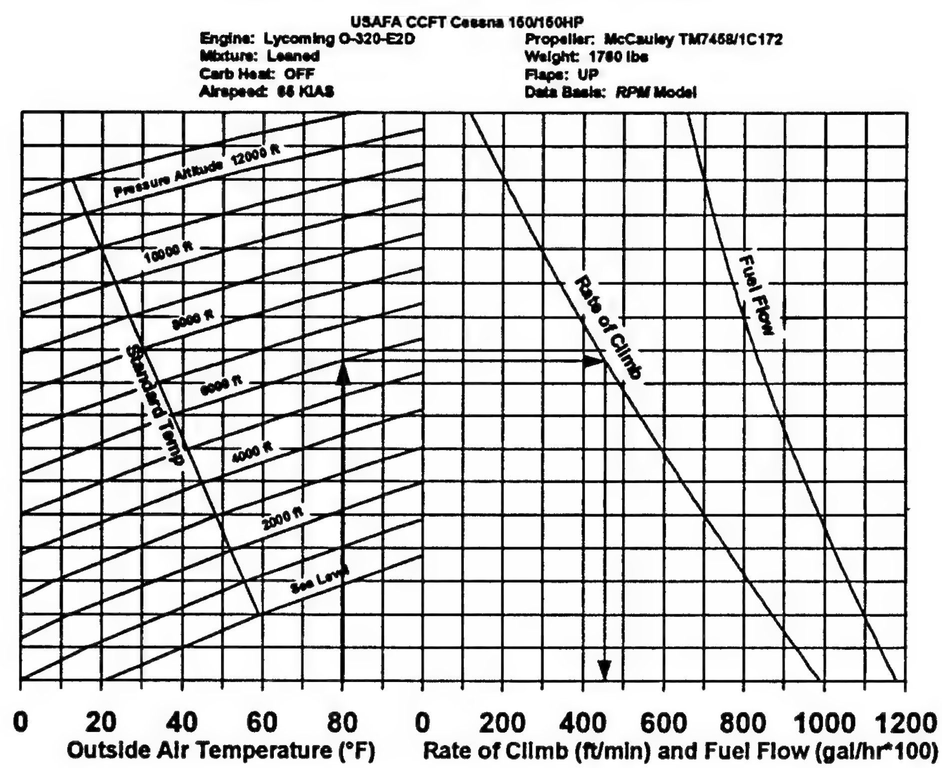

Figure A34 Nonstandard Day Rate of Climb Performance at 65 KIAS

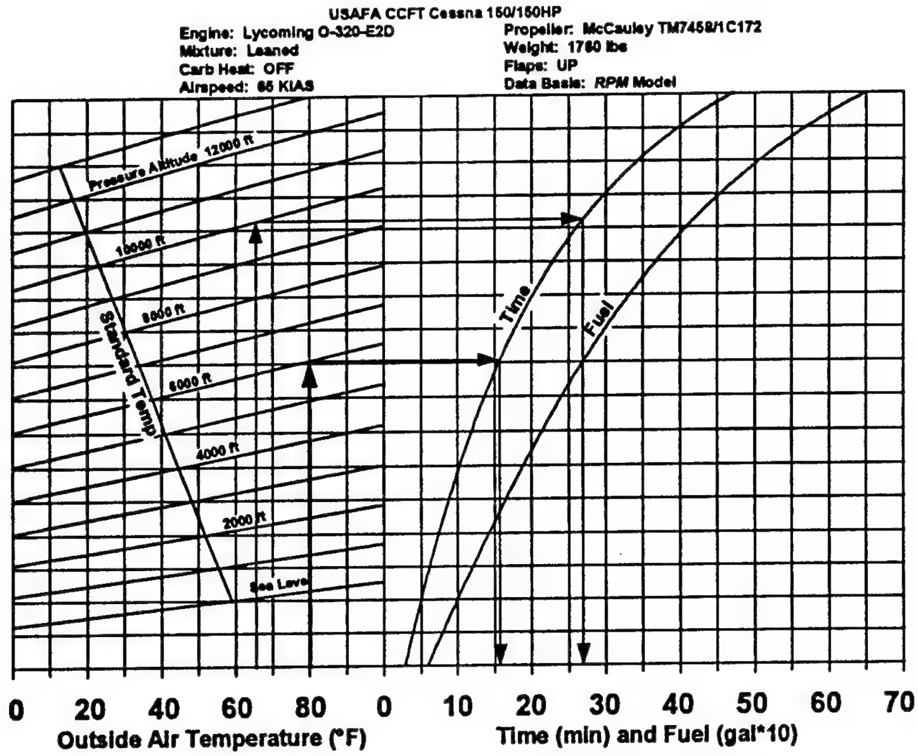

Figure A35 Nonstandard Day Time and Fuel to Climb at 65 KIAS

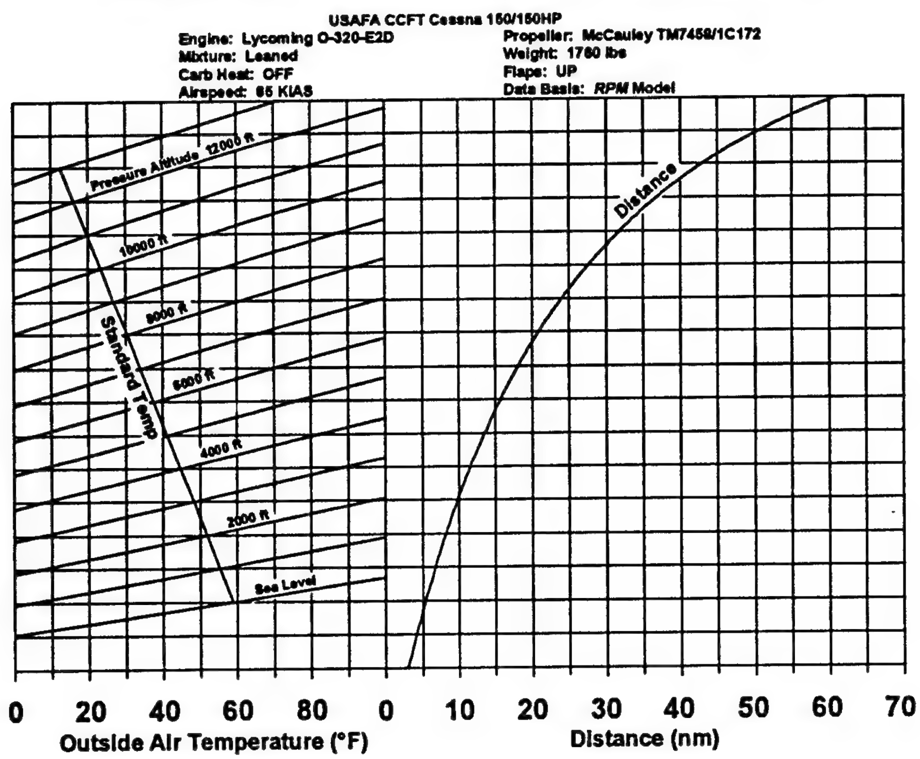

Figure A36 Nonstandard Day Distance to Climb at 65 KIAS

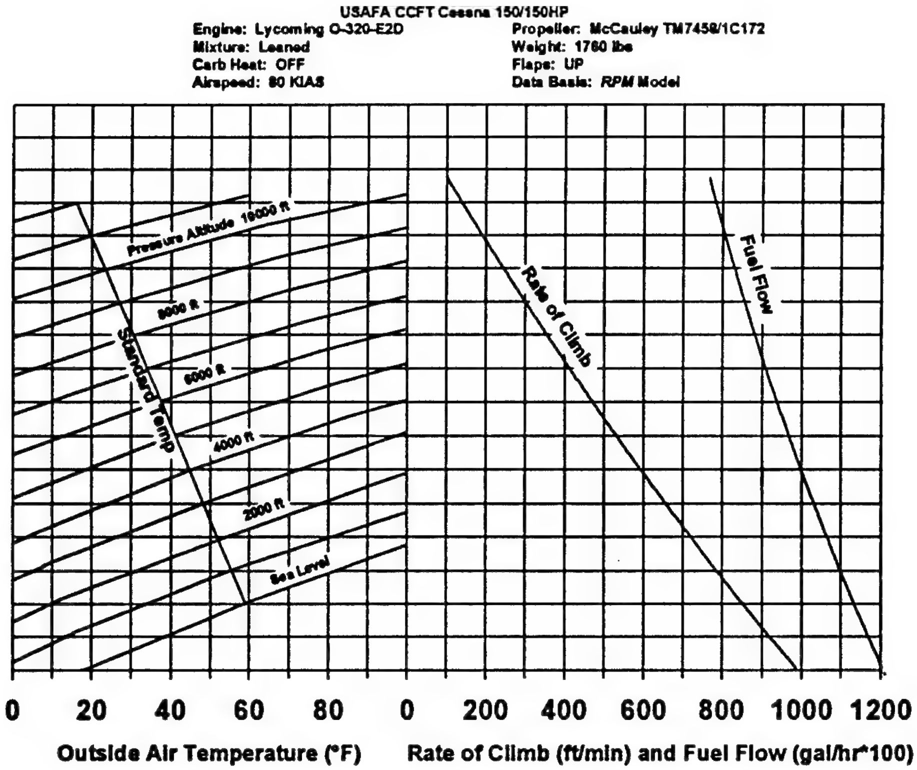

Figure A37 Nonstandard Day Rate of Climb Performance at 80 KIAS

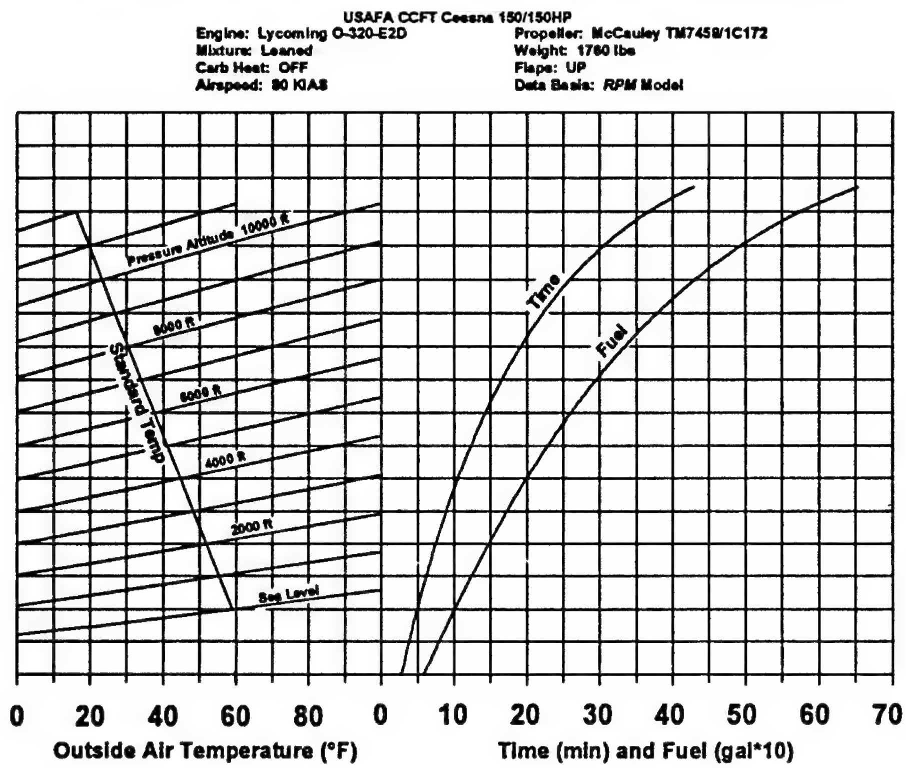

Figure A38 Nonstandard Day Time and Fuel to Climb at 80 KIAS

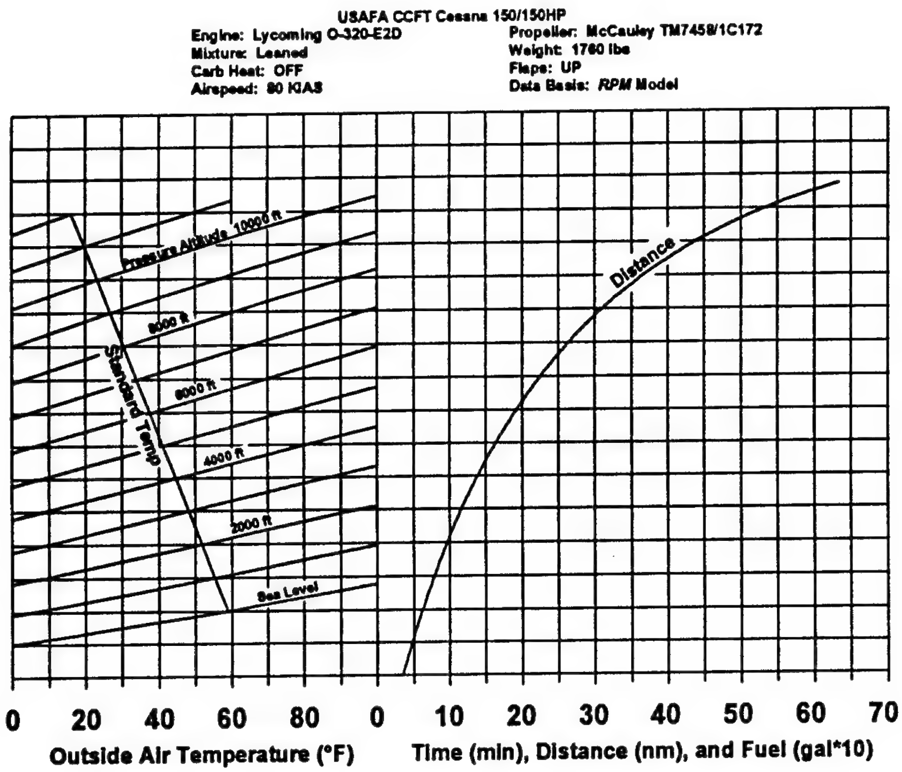

Figure A39 Nonstandard Day Distance to Climb at 80 KIAS

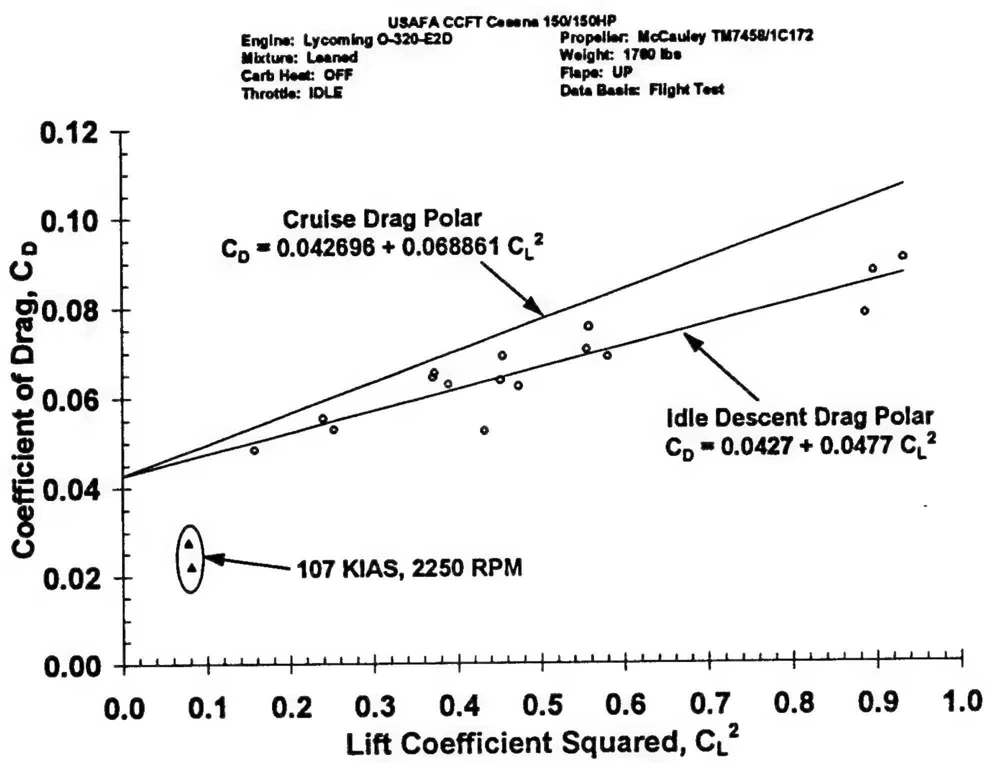

Figure A40 Idle Descent Drag Polar Curve Fit

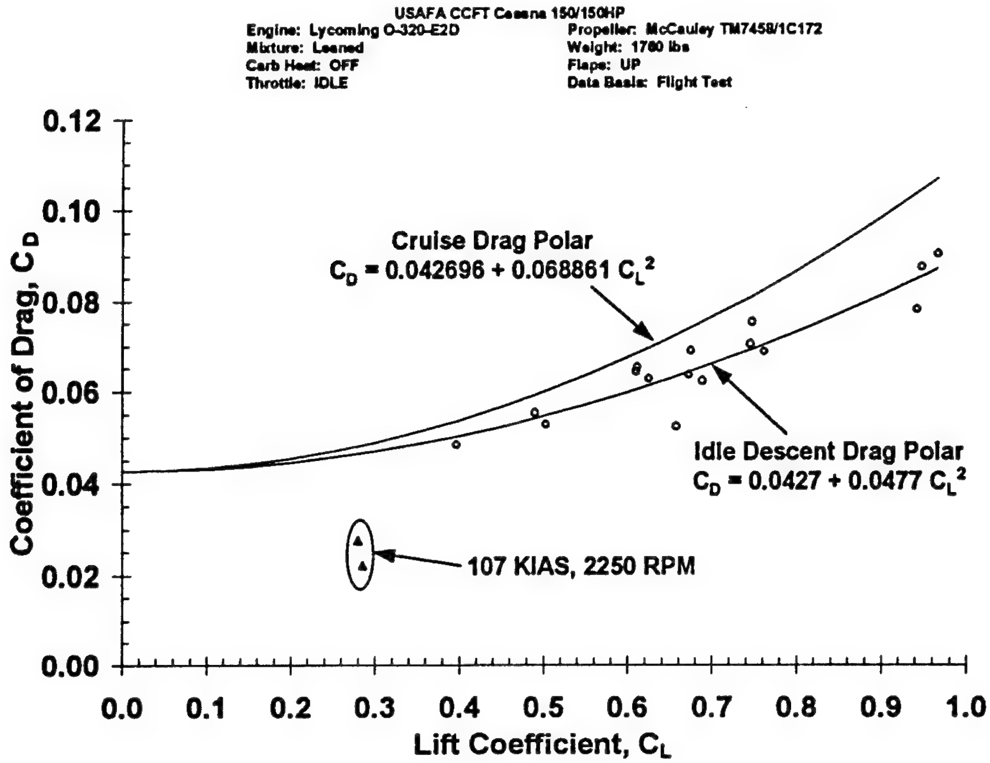

Figure A41 Idle Descent Drag Polar

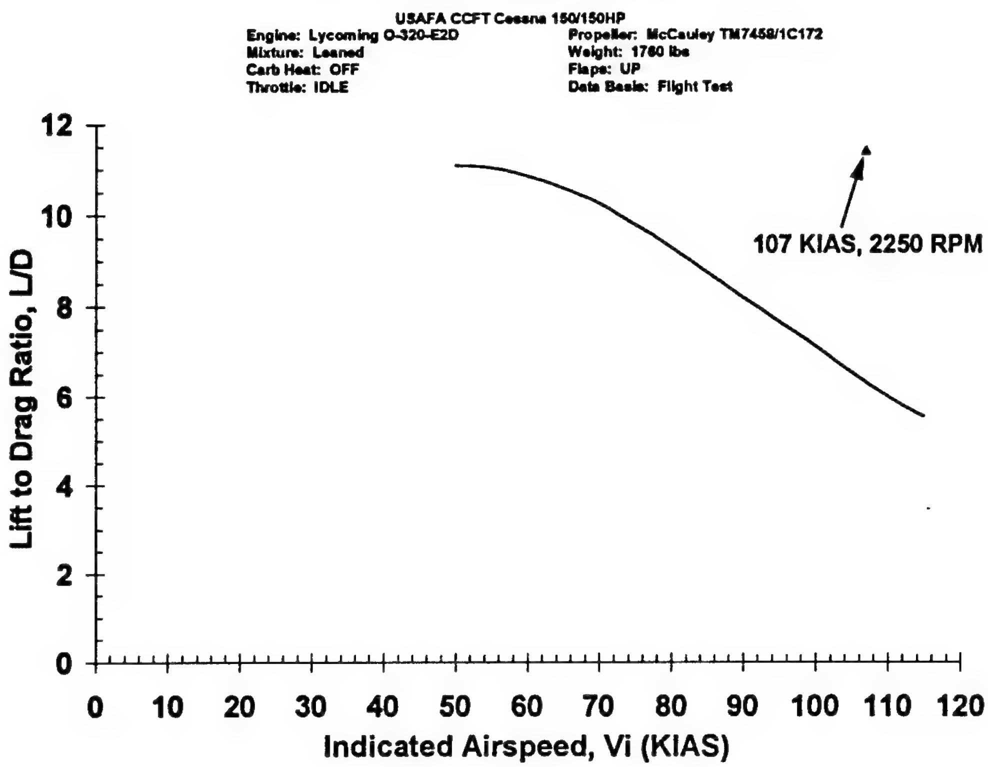

Figure A42 Idle Descent Penetration Chart

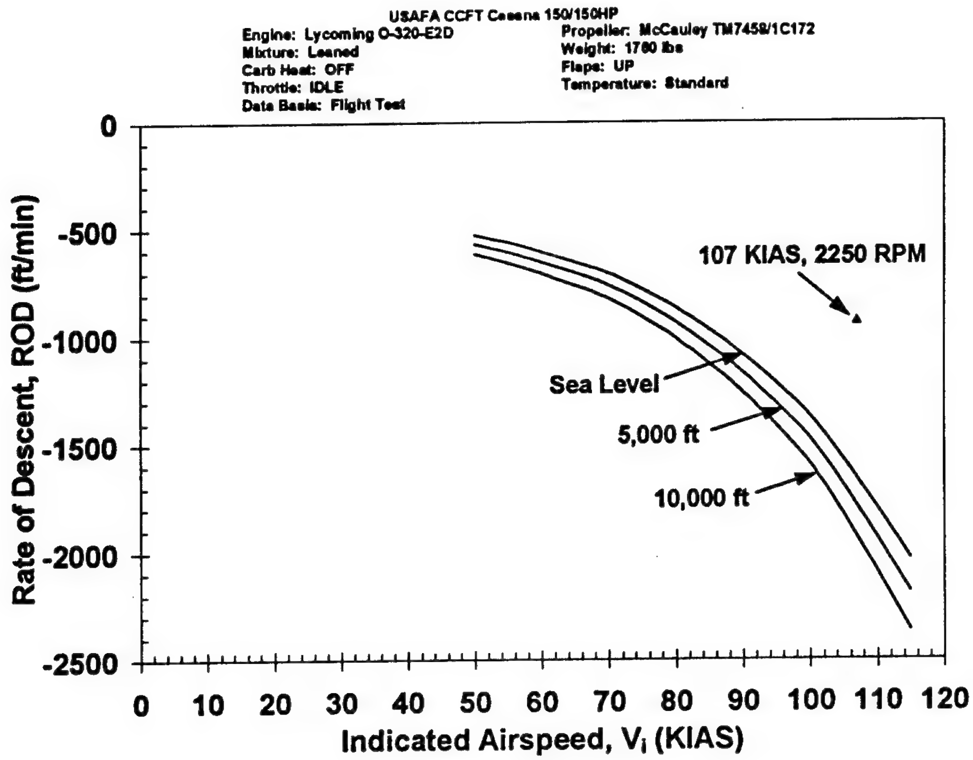

Figure A43 Idle Descent Polar Chart by Indicated Airspeed

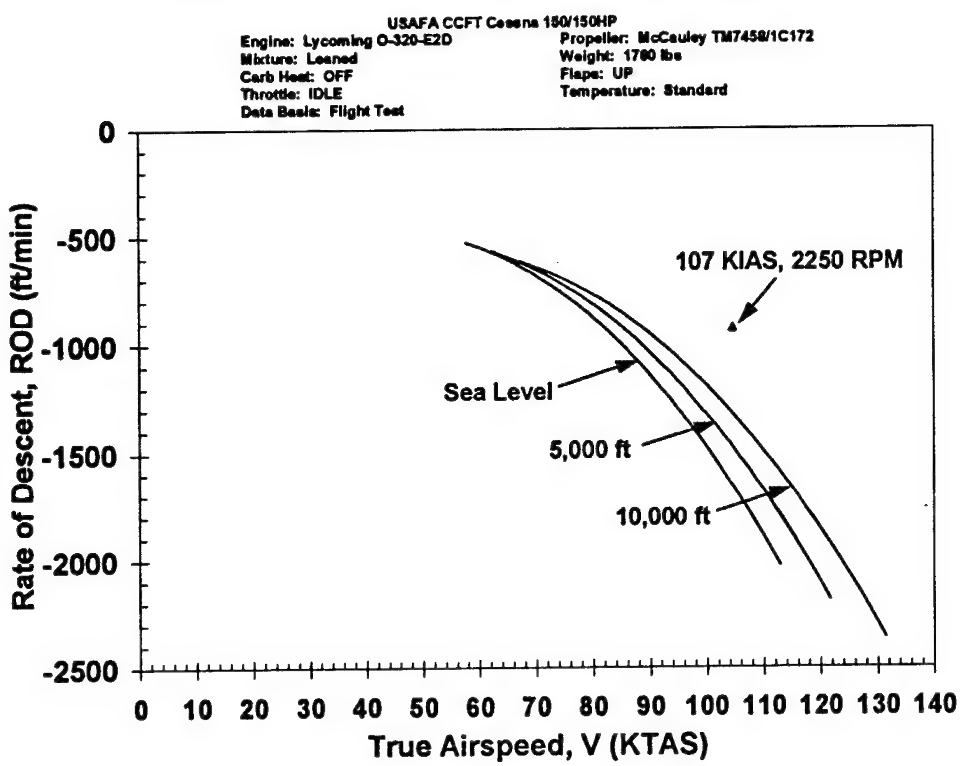

Figure A44 Idle Descent Polar Chart by True Airspeed

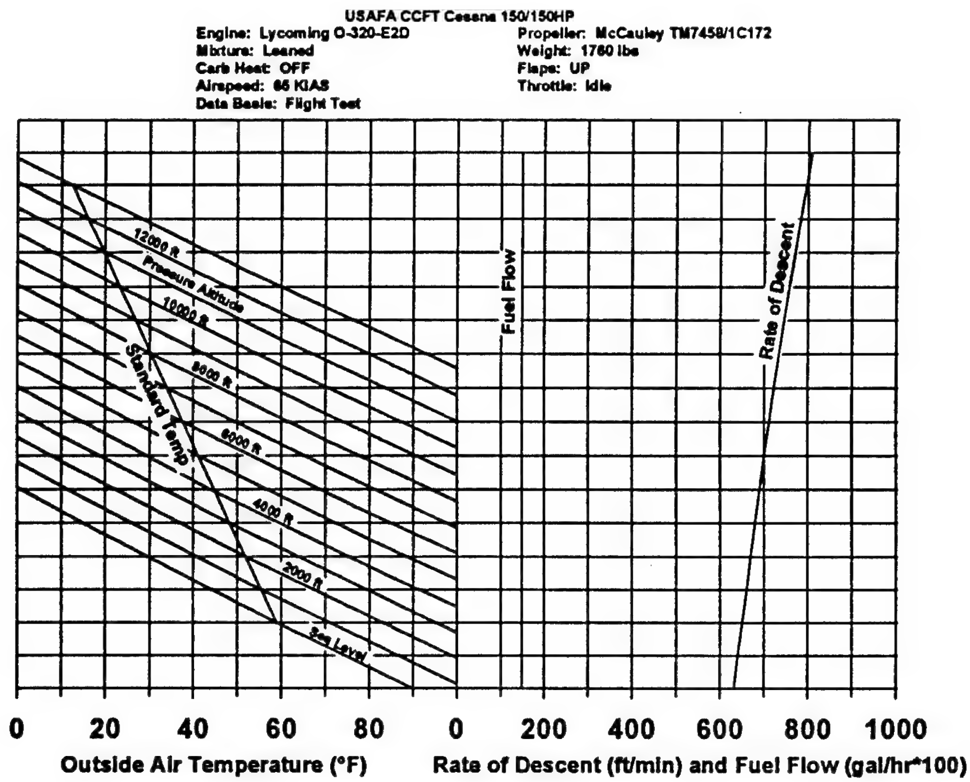

Figure A45 Nonstandard Day Idle Rate of Descent Performance at 65 KIAS

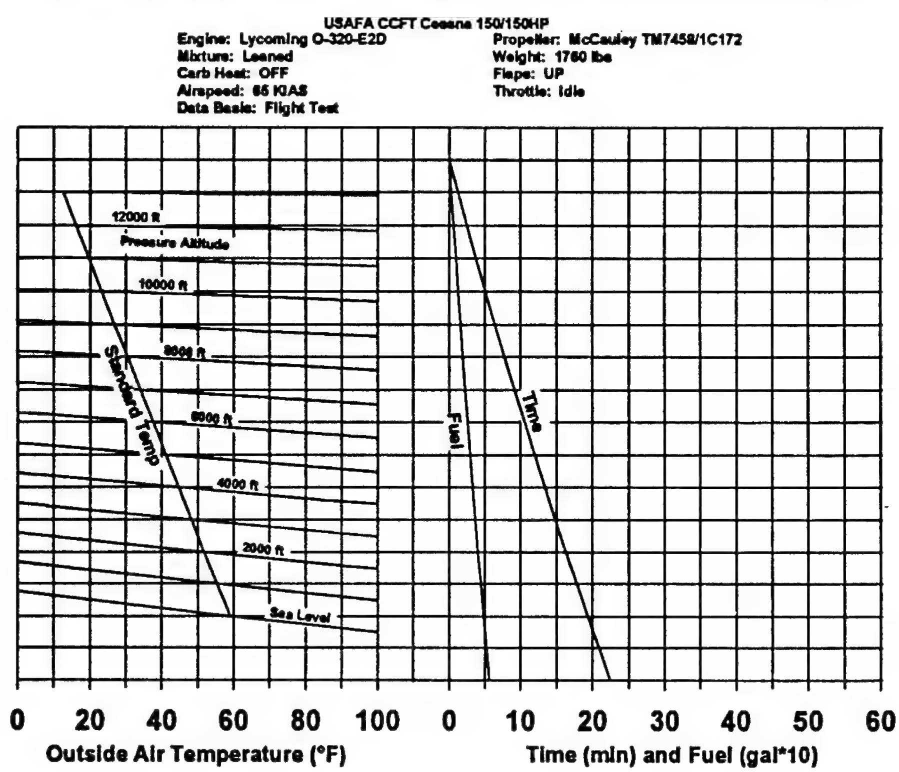

Figure A46 Nonstandard Day Time and Fuel to Descend at Idle at 65 KIAS

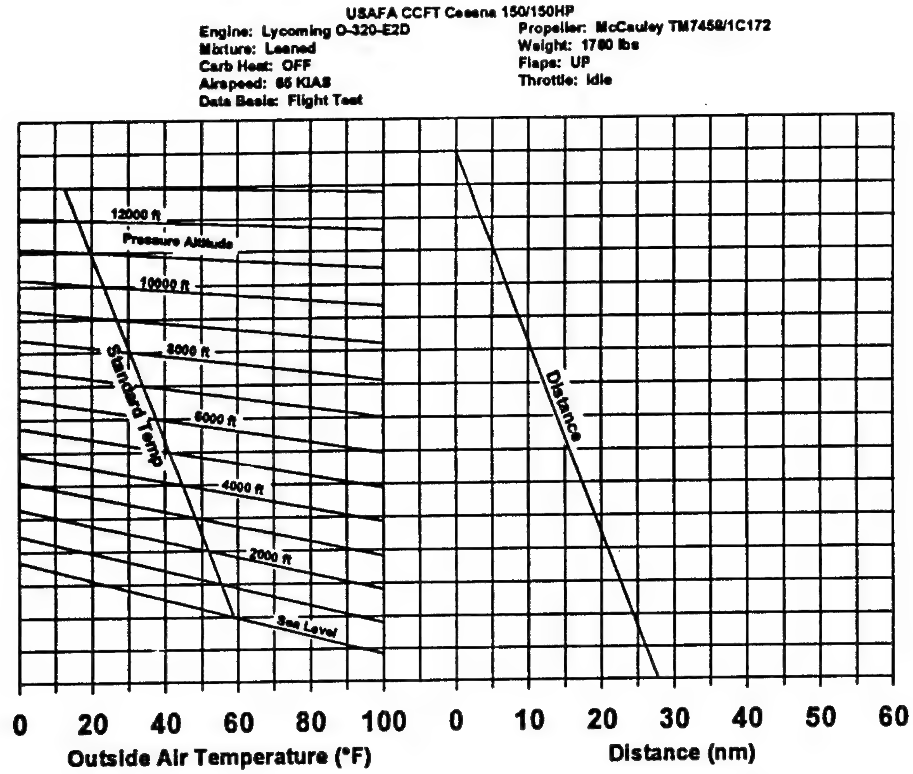

Figure A47 Nonstandard Day Distance to Descend at Idle at 65 KIAS

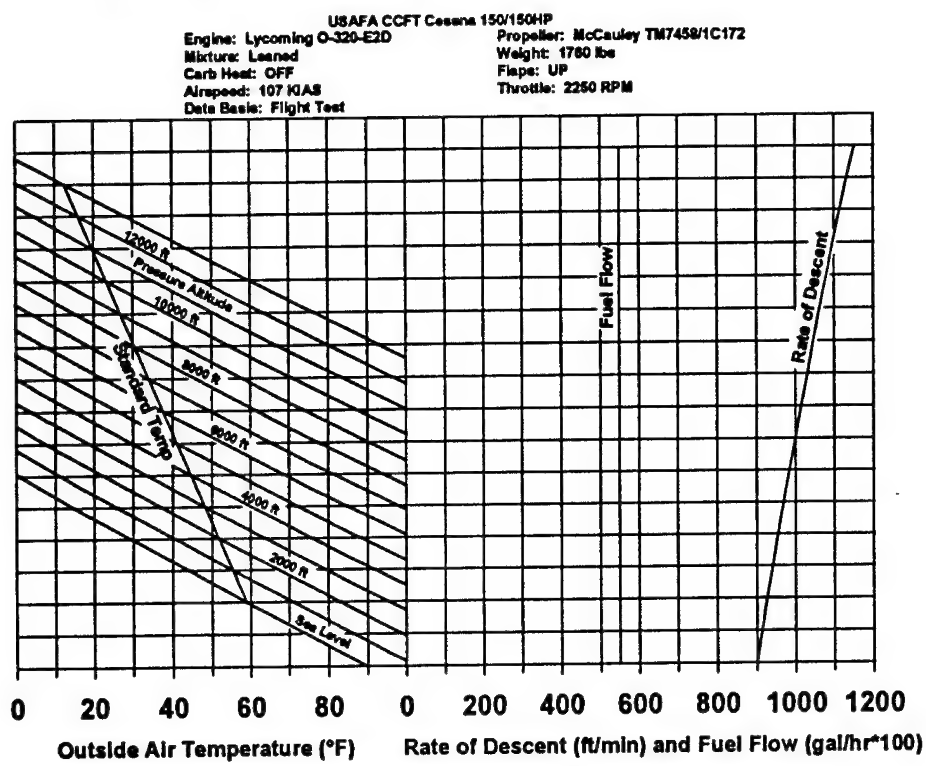

Figure A48 Nonstandard Day Idle Rate of Descent Performance at 107 KIAS, 2250 RPM

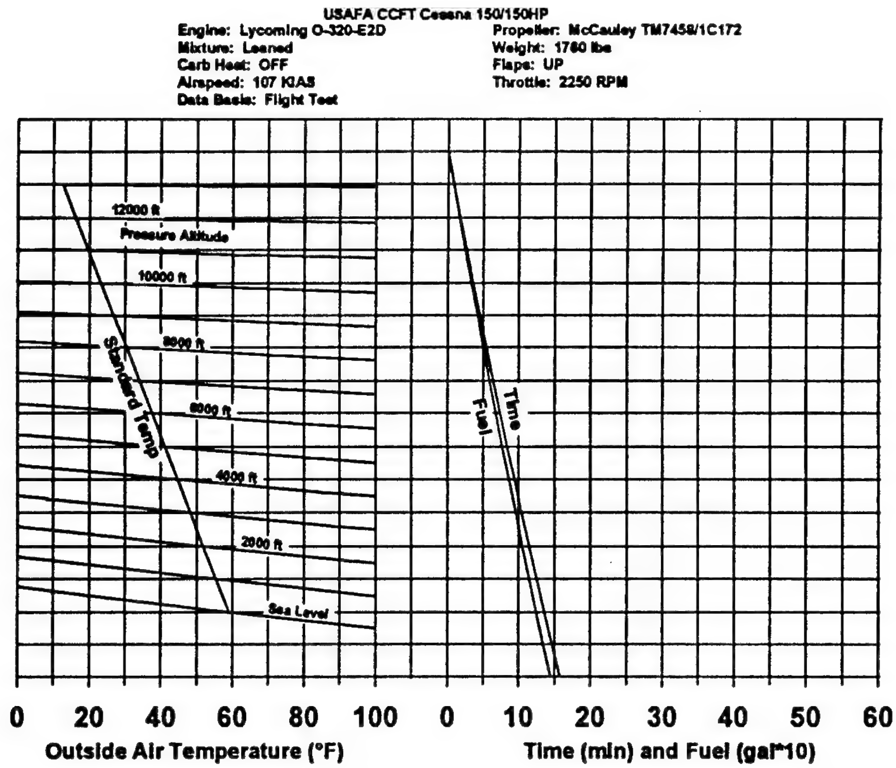

Figure A49 Nonstandard Day Time and Fuel to Descend at 107 KIAS, 2250 RPM

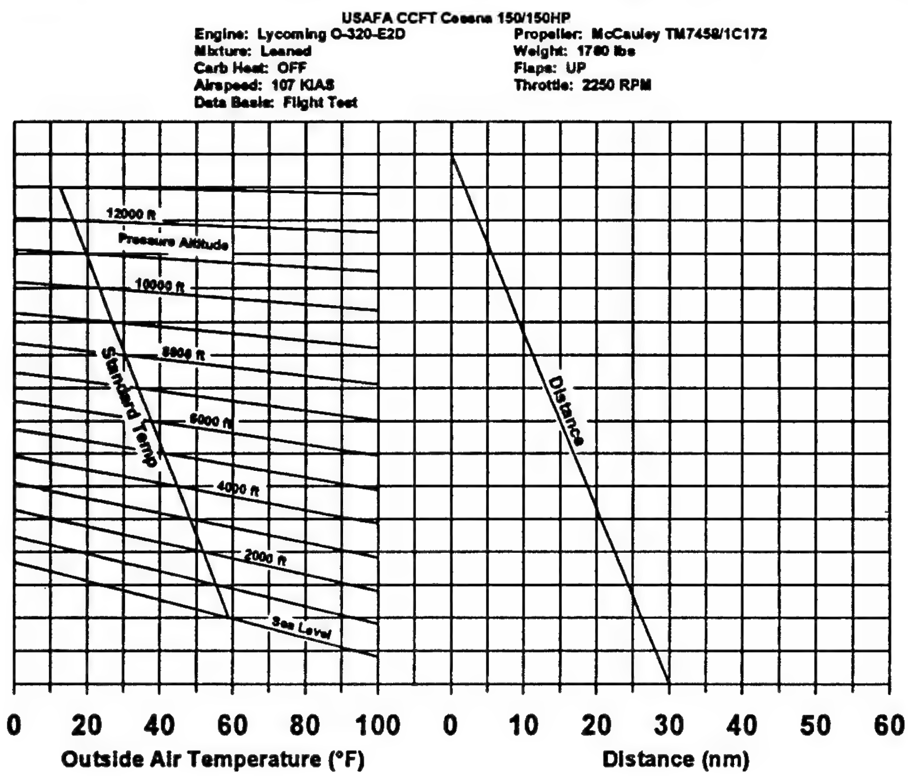

Figure A50 Nonstandard Day Distance to Descend at 107 KIAS, 2250 RPM

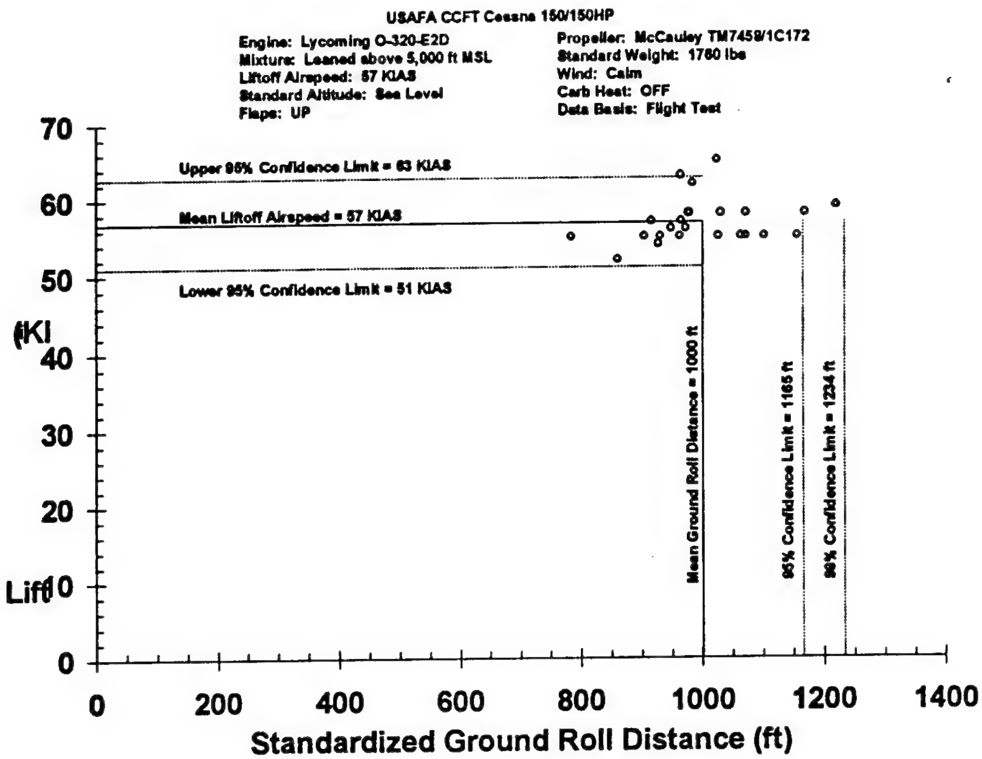

Figure A51 Standardized Takeoff Ground Roll Performance

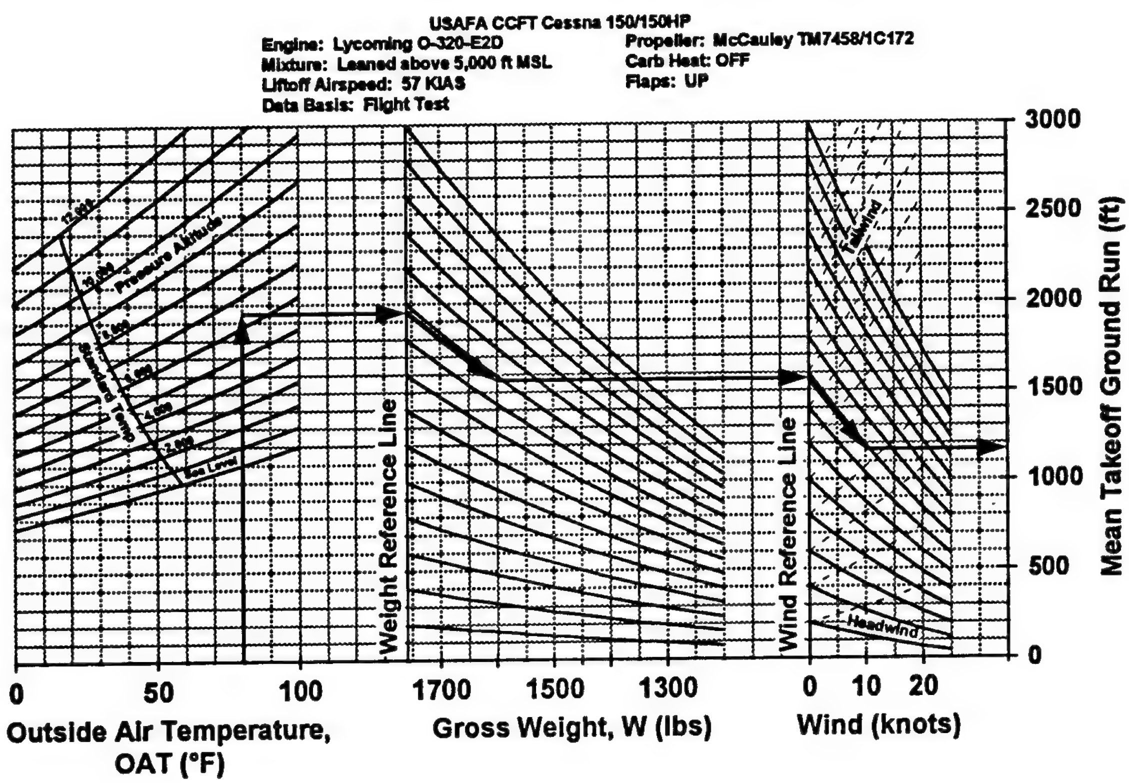

Figure A52 Mean Takeoff Ground Run

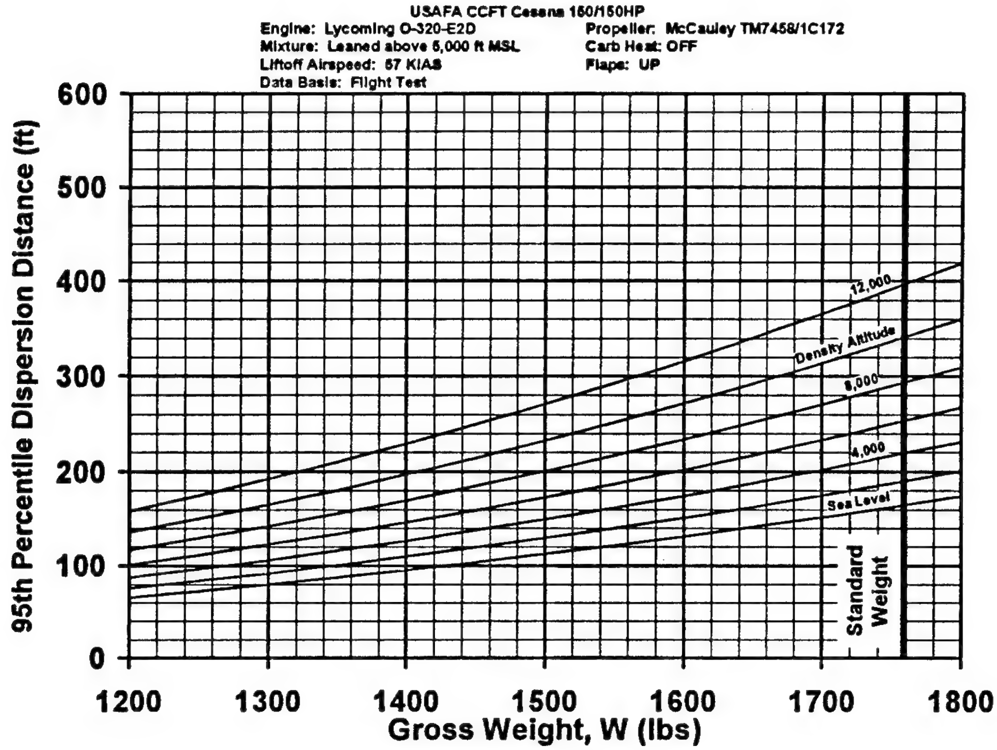

Figure A53 Takeoff 95th Percentile Dispersion

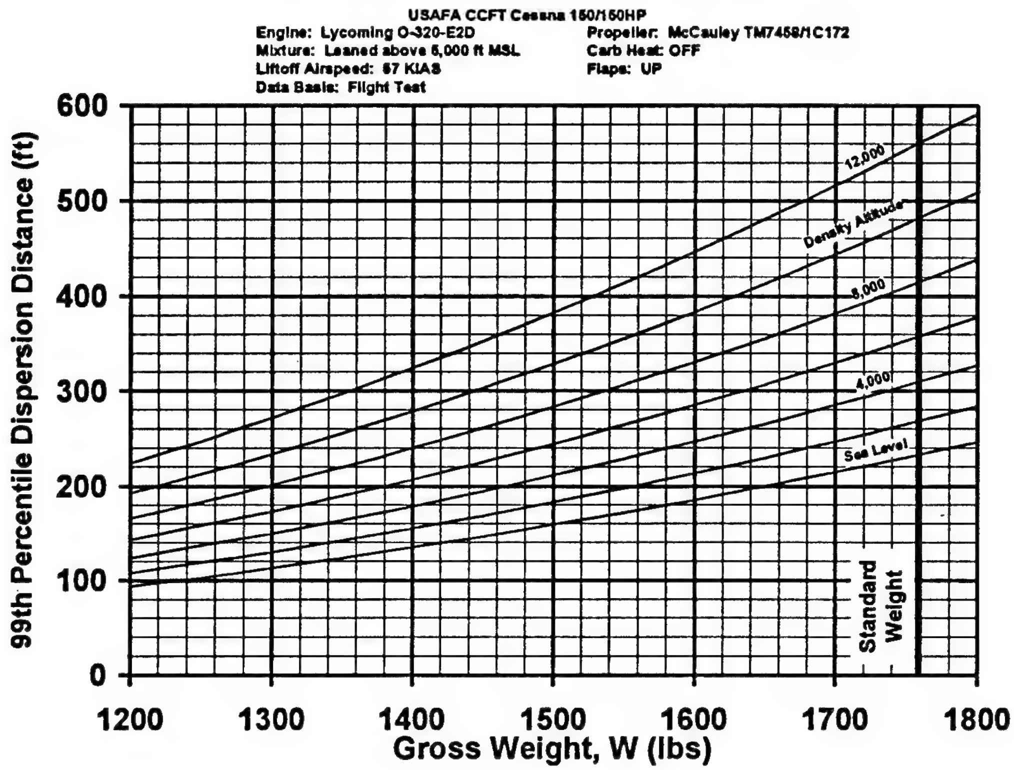

Figure A54 Takeoff 99th Percentile Dispersion

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 1 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
0 (59° F) (15° C)	115	26.0	85	2428	106	12.0	26.5	87	2480	109	12.0	27.0	89	2534	111	12.0
	110	24.5	75	2329	102	10.6	24.9	77	2380	104	10.7	25.3	79	2432	106	10.7
	105	23.1	67	2225	96	9.4	23.5	68	2273	99	9.3	23.8	69	2320	101	9.3
	100	21.9	58	2121	91	8.4	22.2	59	2165	93	8.3	22.5	61	2210	95	8.2
	95	21.0	52	2037	87	7.8	21.2	53	2079	89	7.7	21.5	54	2122	91	7.6
	90	20.2	47	1954	83	7.2	20.5	48	1995	85	7.1	20.7	49	2036	86	7.0
	85	19.7	42	1879	79	6.7	19.8	43	1920	81	6.6	20.0	44	1961	82	6.5
	80	19.2	39	1810	75	6.3	19.4	39	1848	76	6.2	19.5	40	1886	78	6.1
	75	18.9	35	1744	71	6.0	19.0	36	1783	73	5.9	19.1	37	1819	74	5.8
	70	18.6	33	1689	67	5.7	18.7	33	1723	69	5.6	18.8	34	1757	70	5.5
	65	18.4	31	1642	64	5.5	18.5	31	1677	66	5.4	18.6	32	1715	67	5.3
	60	18.4	29	1603	61	5.4	18.4	30	1638	63	5.2	18.5	30	1671	64	5.1
	55	18.3	28	1563	58	5.2	18.3	28	1595	59	5.1	18.4	29	1637	60	5.0
	50						18.4	27	1561	56	5.0	18.4	28	1595	57	4.9
	45						18.4	27	1540	52	4.9	18.4	27	1573	53	4.8
	40															
500 (57° F) (14° C)	115	25.9	86	2450	107	12.1	26.4	88	2505	110	12.2	26.9	90	2556	112	12.1
	110	24.4	76	2351	103	10.7	24.8	78	2401	105	10.8	25.2	79	2452	107	10.8
	105	23.0	67	2243	97	9.4	23.4	69	2293	99	9.4	23.7	70	2339	102	9.4
	100	21.7	59	2137	92	8.4	22.1	60	2185	94	8.4	22.4	61	2230	96	8.3
	95	20.9	53	2054	88	7.8	21.1	54	2098	90	7.7	21.4	55	2141	92	7.6
	90	20.1	47	1973	84	7.2	20.3	48	2014	85	7.1	20.5	49	2055	87	7.0
	85	19.5	43	1897	80	6.7	19.7	44	1939	81	6.6	19.9	44	1979	83	6.5
	80	19.0	39	1825	76	6.3	19.2	40	1864	77	6.2	19.3	40	1902	79	6.1
	75	18.6	36	1763	72	6.0	18.8	36	1799	73	5.9	18.9	37	1837	75	5.8
	70	18.4	33	1703	68	5.7	18.5	34	1738	69	5.6	18.6	34	1774	71	5.5
	65	18.2	31	1656	65	5.5	18.3	31	1692	66	5.4	18.4	32	1726	68	5.3
	60	18.1	29	1614	62	5.3	18.2	30	1651	63	5.2	18.2	30	1683	64	5.1
	55	18.1	28	1576	58	5.2	18.1	29	1609	60	5.1	18.2	29	1652	61	5.0
	50						18.1	28	1583	56	5.0	18.2	28	1606	57	4.8
	45						18.1	27	1549	52	4.9	18.2	28	1589	54	4.8
	40															

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 2 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
0 (59° F) (15° C)	115	27.5	91	2583	113	11.9	28.0	92	2631	115	11.8	28.6	94	2681	117	11.8
	110	25.8	80	2480	108	10.7	26.2	82	2524	110	10.7	26.7	84	2571	112	10.6
	105	24.1	70	2363	103	9.4	24.5	72	2408	105	9.4	24.9	73	2453	106	9.4
	100	22.7	62	2252	97	8.2	23.1	63	2296	99	8.2	23.4	64	2338	101	8.2
	95	21.8	55	2164	93	7.5	22.1	57	2205	94	7.4	22.3	58	2246	96	7.4
	90	20.9	50	2077	88	6.9	21.1	51	2117	90	6.8	21.4	52	2156	91	6.8
	85	20.2	45	2000	84	6.4	20.4	46	2038	85	6.3	20.6	47	2075	87	6.3
	80	19.6	41	1923	80	6.0	19.8	41	1958	81	5.9	19.9	42	1994	83	5.8
	75	19.2	37	1855	76	5.7	19.4	38	1891	77	5.6	19.5	39	1928	78	5.5
	70	18.9	34	1792	72	5.4	19.0	35	1826	73	5.3	19.1	36	1860	74	5.2
	65	18.7	33	1748	68	5.2	18.8	33	1781	70	5.1	18.9	34	1810	71	5.0
	60	18.5	31	1702	65	5.0	18.6	31	1737	66	4.9	18.7	32	1769	68	4.9
	55	18.5	30	1663	61	4.9	18.6	30	1695	63	4.8	18.6	31	1726	64	4.7
	50	18.4	28	1625	58	4.8	18.5	29	1656	59	4.7	18.6	29	1686	60	4.6
	45	18.5	28	1604	54	4.7	18.5	28	1634	55	4.6	18.6	29	1664	56	4.5
	40	18.6	28	1585	50	4.7	18.7	29	1616	51	4.6	18.7	29	1646	52	4.5
500 (57° F) (14° C)	115	27.5	91	2606	114	12.0	27.9	93	2655	116	11.9					
	110	25.7	81	2499	109	10.8	26.2	83	2547	111	10.8	26.7	84	2595	113	10.7
	105	24.1	71	2385	104	9.5	24.5	72	2430	105	9.5	24.8	74	2475	107	9.5
	100	22.7	62	2274	98	8.3	23.0	64	2317	100	8.3	23.3	65	2359	102	8.3
	95	21.7	56	2184	93	7.5	22.0	57	2226	95	7.5	22.2	58	2267	97	7.5
	90	20.8	50	2096	89	6.9	21.0	51	2137	91	6.9	21.3	52	2176	92	6.8
	85	20.0	45	2016	85	6.4	20.2	46	2054	86	6.3	20.5	47	2092	88	6.3
	80	19.5	41	1940	80	6.0	19.6	42	1976	82	5.9	19.8	43	2015	83	5.9
	75	19.1	38	1873	76	5.7	19.2	39	1908	78	5.6	19.4	39	1946	79	5.5
	70	18.7	35	1808	72	5.4	18.8	36	1843	74	5.3	19.0	36	1877	75	5.2
	65	18.5	33	1760	69	5.2	18.6	33	1793	70	5.1	18.7	34	1827	72	5.0
	60	18.3	31	1716	66	5.0	18.4	32	1753	67	4.9	18.5	32	1786	68	4.9
	55	18.3	30	1677	62	4.9	18.4	30	1708	63	4.8	18.4	31	1738	64	4.7
	50	18.2	29	1649	58	4.8	18.3	29	1674	60	4.7	18.4	30	1704	61	4.6
	45	18.3	28	1619	55	4.7	18.3	29	1642	56	4.6	18.4	29	1673	57	4.5
	40	18.4	28	1595	51	4.7	18.4	28	1629	52	4.6	18.5	29	1664	53	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 3 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D Mixture: Leaned Weight: 1760 lbs Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172 Carb Heat: OFF Flaps: UP

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
1000 (55° F) (13° C)	115	25.8	86	2472	108	12.2	26.4	89	2527	111	12.2	26.9	90	2579	113	12.1
	110	24.4	77	2373	104	10.9	24.8	78	2422	106	10.9	25.2	80	2473	108	10.9
	105	22.9	68	2265	98	9.5	23.2	69	2312	100	9.5	23.6	70	2360	102	9.5
	100	21.6	59	2159	93	8.5	22.0	61	2204	95	8.4	22.3	62	2249	97	8.4
	95	20.8	53	2074	89	7.8	21.0	54	2117	91	7.7	21.3	55	2161	92	7.6
	90	20.0	48	1990	84	7.2	20.2	49	2032	86	7.1	20.4	50	2074	88	7.0
	85	19.4	43	1916	80	6.7	19.5	44	1957	82	6.6	19.7	45	1997	84	6.5
	80	18.9	39	1842	76	6.3	19.0	40	1881	78	6.2	19.2	41	1921	79	6.1
	75	18.4	36	1777	72	6.0	18.6	37	1815	74	5.9	18.8	37	1853	75	5.8
	70	18.2	33	1718	69	5.7	18.3	34	1754	70	5.6	18.4	34	1789	71	5.5
	65	18.0	31	1674	65	5.5	18.1	32	1707	67	5.4	18.2	32	1742	68	5.3
	60	17.9	30	1632	62	5.3	18.0	30	1665	64	5.2	18.0	31	1698	65	5.1
	55	17.9	28	1590	59	5.2	18.0	29	1634	60	5.1	18.0	30	1660	61	5.0
	50	17.9	27	1558	55	5.1	17.9	28	1591	57	5.0	18.0	29	1632	58	4.9
	45						18.0	27	1561	53	4.9	18.0	28	1595	54	4.8
	40															
1500 (54° F) (12° C)	110	24.3	78	2395	104	11.0	24.7	79	2445	107	11.0	25.2	81	2496	109	11.0
	105	22.8	68	2285	99	9.6	23.2	70	2334	101	9.6	23.6	71	2381	103	9.6
	100	21.5	60	2177	94	8.5	21.8	61	2224	96	8.4	22.2	62	2270	98	8.4
	95	20.6	54	2092	89	7.8	20.9	55	2136	91	7.7	21.2	56	2181	93	7.7
	90	19.9	48	2008	85	7.3	20.1	49	2051	87	7.1	20.3	50	2093	89	7.1
	85	19.2	44	1931	81	6.8	19.4	44	1972	83	6.6	19.6	45	2013	84	6.5
	80	18.7	39	1858	77	6.3	18.8	40	1898	79	6.2	19.0	41	1936	80	6.1
	75	18.4	36	1795	73	6.0	18.5	37	1833	75	5.9	18.6	38	1870	76	5.8
	70	18.1	34	1734	69	5.7	18.1	34	1769	71	5.6	18.3	35	1806	72	5.5
	65	17.8	32	1690	66	5.5	17.9	32	1722	67	5.4	18.0	33	1758	69	5.3
	60	17.7	30	1644	63	5.3	17.8	30	1681	64	5.2	17.9	31	1718	66	5.1
	55	17.7	29	1613	59	5.2	17.7	29	1640	61	5.1	17.8	30	1673	62	4.9
	50	17.6	27	1566	56	5.0	17.7	28	1614	57	5.0	17.8	29	1641	58	4.9
	45						17.8	27	1576	53	4.9	17.8	28	1618	54	4.8
	40															

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 4 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis: *RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP	

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
1000 (55° F) (13° C)	115	27.4	92	2628	115	12.0	28.1	94	2680	117	12.1					
	110	25.7	82	2522	110	10.9	26.2	84	2571	112	10.8	26.6	85	2618	114	10.8
	105	24.0	72	2406	104	9.6	24.4	73	2452	106	9.6	24.8	75	2498	108	9.6
	100	22.6	63	2294	99	8.3	22.9	64	2338	101	8.4	23.2	65	2381	103	8.4
	95	21.6	57	2204	94	7.6	21.9	58	2246	96	7.5	22.2	59	2288	98	7.5
	90	20.7	51	2116	90	7.0	20.9	52	2156	91	6.9	21.2	53	2196	93	6.8
	85	19.9	46	2035	85	6.4	20.1	47	2074	87	6.4	20.4	48	2112	89	6.3
	80	19.3	41	1959	81	6.0	19.5	42	1997	83	5.9	19.7	43	2033	84	5.9
	75	18.9	38	1890	77	5.7	19.1	39	1928	78	5.6	19.2	40	1963	80	5.5
	70	18.5	35	1825	73	5.4	18.7	36	1861	74	5.3	18.8	37	1894	76	5.2
	65	18.3	33	1777	70	5.2	18.4	34	1810	71	5.1	18.5	34	1844	72	5.0
	60	18.1	31	1736	66	5.0	18.2	32	1765	68	4.9	18.3	33	1797	69	4.8
	55	18.1	30	1692	63	4.9	18.1	30	1722	64	4.8	18.2	31	1753	65	4.7
	50	18.0	29	1658	59	4.8	18.1	30	1689	60	4.7	18.2	30	1719	61	4.6
	45	18.1	29	1635	55	4.7	18.1	29	1656	56	4.6	18.2	30	1697	57	4.6
	40	18.2	28	1617	51	4.7	18.3	29	1649	52	4.6	18.3	29	1679	53	4.5
1500 (54° F) (12° C)	110	25.7	83	2546	111	11.0	26.2	84	2595	113	10.9	26.6	86	2642	115	10.9
	105	23.9	72	2428	105	9.7	24.4	74	2475	107	9.7	24.8	75	2521	109	9.7
	100	22.5	63	2315	100	8.4	22.8	65	2358	102	8.4	23.1	66	2401	104	8.5
	95	21.5	57	2224	95	7.6	21.8	58	2267	97	7.6	22.1	59	2310	99	7.6
	90	20.6	51	2135	91	7.0	20.8	52	2175	92	6.9	21.1	53	2216	94	6.9
	85	19.8	46	2053	86	6.5	20.0	47	2093	88	6.4	20.2	48	2131	89	6.3
	80	19.2	42	1975	82	6.0	19.4	43	2015	83	6.0	19.5	43	2049	85	5.9
	75	18.8	39	1909	78	5.7	18.9	39	1945	79	5.6	19.0	40	1978	81	5.5
	70	18.4	36	1842	74	5.4	18.5	36	1877	75	5.3	18.7	37	1915	76	5.3
	65	18.2	33	1793	70	5.2	18.3	34	1828	72	5.1	18.4	35	1861	73	5.0
	60	18.0	32	1753	67	5.0	18.1	32	1786	68	4.9	18.2	33	1814	69	4.8
	55	17.8	30	1705	63	4.8	17.9	31	1741	64	4.8	18.0	31	1773	66	4.7
	50	17.9	29	1672	60	4.8	18.0	30	1703	61	4.7	18.0	30	1734	62	4.6
	45	17.9	28	1640	56	4.7	18.0	29	1677	57	4.6	18.1	30	1708	58	4.5
	40	17.9	28	1626	52	4.7	18.1	29	1666	53	4.6	18.2	30	1687	54	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 5 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
2000 (52° F) (11° C)	110	24.3	79	2417	105	11.1	24.7	80	2467	108	11.1	25.1	82	2519	110	11.1
	105	22.7	68	2306	100	9.6	23.1	70	2354	102	9.7	23.5	72	2403	104	9.8
	100	21.5	60	2198	95	8.6	21.7	61	2243	97	8.5	2[illegible].1	63	2290	99	8.5
	95	20.5	54	2110	90	7.9	20.8	55	2156	92	7.8	21.1	57	2201	94	7.7
	90	19.7	49	2028	86	7.3	20.0	50	2069	88	7.2	20.2	51	2112	90	7.1
	85	19.0	44	1949	82	6.7	19.3	45	1991	84	6.7	19.5	46	2033	85	6.6
	80	18.5	40	1874	78	6.3	18.7	41	1915	79	6.2	18.9	41	1956	81	6.1
	75	18.2	37	1811	74	6.0	18.3	38	1852	75	5.9	18.5	38	1890	77	5.8
	70	17.8	34	1751	70	5.7	18.0	34	1785	71	5.6	18.1	35	1823	73	5.5
	65	17.7	32	1705	67	5.5	17.8	32	1739	68	5.4	17.9	33	1774	69	5.3
	60	17.6	30	1662	63	5.3	17.6	31	1695	65	5.2	17.7	31	1730	66	5.1
	55	17.5	29	1625	60	5.2	17.5	29	1654	61	5.0	17.6	30	1687	63	4.9
	50	17.5	28	1584	56	5.1	17.5	28	1620	58	4.9	17.6	29	1656	59	4.9
	45	17.6	28	1570	53	5.0	17.6	28	1591	54	4.9	17.6	28	1625	55	4.8
	40											17.6	28	1600	51	4.7
2500 (50° F) (10° C)	110	24.2	79	2439	106	11.2	24.7	81	2492	109	11.3	25.1	83	2543	111	11.2
	105	22.6	69	2326	101	9.7	23.0	71	2376	103	9.8	23.4	72	2425	105	9.9
	100	21.4	61	2218	96	8.6	21.6	62	2264	98	8.6	22.0	63	2310	100	8.5
	95	20.4	55	2133	91	7.9	20.7	56	2177	93	7.8	21.0	57	2222	95	7.8
	90	19.6	49	2045	87	7.3	19.9	50	2089	89	7.2	20.1	51	2132	90	7.1
	85	19.0	44	1969	83	6.8	19.1	45	2009	84	6.7	19.4	46	2051	86	6.6
	80	18.4	40	1894	78	6.3	18.5	41	1933	80	6.2	18.7	42	1975	82	6.1
	75	18.0	37	1827	74	6.0	18.1	38	1865	76	5.9	18.3	38	1905	78	5.8
	70	17.6	34	1764	70	5.7	17.8	35	1802	72	5.6	18.0	36	1840	73	5.5
	65	17.5	32	1721	67	5.5	17.6	33	1754	69	5.4	17.7	33	1790	70	5.3
	60	17.4	31	1680	64	5.3	17.4	31	1715	65	5.2	17.5	32	1750	67	5.1
	55	17.3	29	1642	61	5.2	17.3	30	1669	62	5.0	17.4	30	1702	63	4.9
	50	17.3	28	1602	57	5.0	17.4	29	1644	58	5.0	17.4	29	1668	59	4.8
	45	17.4	28	1576	53	5.0	17.4	28	1607	54	4.9	17.5	29	1649	55	4.8
	40						17.4	28	1596	51	4.8	17.6	29	1633	52	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 6 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
2000 (52° F) (11° C)	110	25.6	84	2569	112	11.0	26.1	85	2619	114	11.0	26.6	87	2667	116	11.0
	105	23.9	73	2451	106	9.8	24.3	75	2498	108	9.8	24.7	76	2544	110	9.7
	100	22.4	64	2335	101	8.5	22.7	65	2380	103	8.6	23.1	66	2423	104	8.6
	95	21.4	58	2245	96	7.7	21.7	59	2288	98	7.6	21.9	59	2327	100	7.6
	90	20.4	52	2154	91	7.0	20.7	53	2196	93	6.9	21.0	54	2236	95	6.9
	85	19.7	47	2072	87	6.5	19.9	48	2112	89	6.4	20.1	48	2150	90	6.3
	80	19.0	42	1993	83	6.0	19.2	43	2031	84	6.0	19.4	44	2069	86	5.9
	75	18.6	39	1926	78	5.7	18.7	39	1960	80	5.6	18.9	40	1998	81	5.5
	70	18.2	36	1859	74	5.4	18.4	37	1895	76	5.3	18.6	37	1932	77	5.3
	65	18.0	34	1809	71	5.2	18.1	34	1844	72	5.1	18.3	35	1878	74	5.0
	60	17.8	32	1764	67	5.0	17.9	33	1798	69	4.9	18.0	33	1831	70	4.9
	55	17.7	31	1725	64	4.9	17.8	31	1758	65	4.8	17.9	32	1785	66	4.7
	50	17.7	30	1687	60	4.8	17.7	30	1719	61	4.7	17.8	31	1752	62	4.6
	45	17.7	29	1666	56	4.7	17.8	29	1691	57	4.6	17.9	30	1722	58	4.5
	40	17.8	29	1651	52	4.7	17.9	29	1672	53	4.6	18.0	30	1712	54	4.5
2500 (50° F) (10° C)	110	25.6	84	2593	113	11.1	26.1	86	2644	115	11.1					
	105	23.9	74	2474	107	9.9	24.3	75	2521	109	9.9	24.7	77	2568	111	9.8
	100	22.3	65	2357	102	8.6	22.7	66	2402	104	8.7	23.0	67	2446	105	8.7
	95	21.4	58	2267	97	7.8	21.5	59	2307	99	7.7	21.8	60	2349	101	7.7
	90	20.4	52	2174	92	7.0	20.6	53	2216	94	7.0	20.9	54	2257	96	7.0
	85	19.6	47	2092	88	6.5	19.8	48	2131	89	6.4	20.0	49	2170	91	6.4
	80	18.9	43	2012	83	6.1	19.1	43	2051	85	6.0	19.3	44	2088	86	5.9
	75	18.4	39	1942	79	5.7	18.6	40	1980	81	5.6	18.7	41	2016	82	5.5
	70	18.1	36	1876	75	5.4	18.3	37	1914	76	5.3	18.4	38	1950	78	5.3
	65	17.8	34	1827	71	5.2	18.0	35	1861	73	5.1	18.1	35	1895	74	5.0
	60	17.6	32	1780	68	5.0	17.8	33	1814	69	4.9	17.9	34	1849	71	4.9
	55	17.5	31	1736	64	4.8	17.6	31	1770	66	4.8	17.7	32	1802	67	4.7
	50	17.5	30	1701	61	4.7	17.6	30	1737	62	4.7	17.7	31	1768	63	4.6
	45	17.5	29	1675	57	4.7	17.6	30	1706	58	4.6	17.7	30	1736	59	4.5
	40	17.6	29	1664	53	4.7	17.7	30	1694	54	4.6	17.8	30	1725	55	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 7 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
3000	110	24.1	80	2462	107	11.3	24.6	82	2514	110	11.4	25.1	83	2566	112	11.3
(48° F)	105	22.6	70	2349	102	9.9	23.0	72	2398	104	10.0	23.4	73	2448	106	10.0
(9° C)	100	21.3	61	2238	96	8.7	21.6	63	2285	99	8.6	21.9	64	2332	101	8.7
	95	20.3	55	2149	92	7.9	20.6	56	2196	94	7.8	20.9	57	2241	96	7.8
	90	19.5	50	2065	87	7.3	19.7	51	2108	89	7.2	20.0	52	2152	91	7.1
	85	18.8	45	1988	83	6.8	19.0	46	2028	85	6.7	19.2	47	2070	87	6.6
	80	18.3	41	1912	79	6.4	18.4	41	1951	81	6.2	18.6	42	1991	82	6.2
	75	17.9	37	1844	75	6.0	18.0	38	1882	77	5.9	18.1	39	1923	78	5.8
	70	17.6	35	1782	71	5.7	17.7	35	1820	73	5.6	17.8	36	1857	74	5.5
	65	17.3	32	1732	68	5.5	17.5	33	1771	69	5.4	17.6	34	1807	71	5.3
	60	17.2	31	1695	65	5.3	17.3	31	1726	66	5.2	17.4	32	1762	67	5.1
	55	17.1	29	1650	61	5.1	17.2	30	1685	62	5.0	17.3	30	1723	64	4.9
	50	17.1	28	1615	58	5.0	17.1	29	1650	59	4.9	17.2	29	1687	60	4.8
	45	17.2	28	1592	54	5.0	17.2	29	1632	55	4.9	17.3	29	1657	56	4.8
	40	17.2	27	1571	50	4.9	17.3	28	1608	51	4.8	17.4	29	1640	52	4.7
3500	105	22.4	70	2366	103	10.0	22.9	72	2420	105	10.1	23.4	74	2471	107	10.1
(47° F)	100	21.2	62	2259	97	8.8	21.5	63	2306	99	8.7	21.8	64	2353	101	8.8
(8° C)	95	20.2	56	2171	93	8.0	20.5	57	2215	95	7.9	20.8	58	2262	97	7.9
	90	19.4	50	2084	88	7.3	19.6	51	2128	90	7.2	19.9	52	2173	92	7.2
	85	18.7	45	2006	84	6.8	18.9	46	2047	86	6.7	19.1	47	2090	88	6.6
	80	18.1	41	1927	80	6.3	18.3	42	1969	81	6.3	18.5	43	2010	83	6.2
	75	17.7	38	1860	76	6.0	17.8	38	1899	77	5.9	18.0	39	1938	79	5.8
	70	17.4	35	1798	72	5.7	17.5	35	1836	73	5.6	17.7	36	1877	75	5.5
	65	17.1	32	1747	68	5.5	17.3	33	1787	70	5.4	17.4	34	1824	71	5.3
	60	17.1	31	1710	65	5.3	17.1	32	1744	67	5.2	17.2	32	1779	68	5.1
	55	16.9	30	1668	62	5.1	17.0	30	1700	63	5.0	17.1	31	1734	64	4.9
	50	16.9	29	1633	58	5.0	16.9	29	1665	59	4.9	17.0	30	1703	61	4.8
	45	17.0	28	1603	54	5.0	17.0	29	1640	55	4.9	17.1	29	1672	57	4.8
	40	17.0	28	1585	50	4.9	17.1	29	1631	51	4.9	17.2	29	1661	53	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 8 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis: *RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP	

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
3000	110	25.6	85	2618	114	11.2										
(48° F)	105	23.8	75	2497	108	10.0	24.2	76	2544	110	9.9	24.7	77	2591	112	9.9
(9° C)	100	22.3	65	2378	103	8.7	22.6	66	2424	104	8.8	23.0	68	2469	106	8.8
	95	21.2	59	2286	98	7.8	21.5	59	2328	100	7.8	21.8	61	2371	101	7.8
	90	20.3	53	2195	93	7.1	20.5	54	2237	95	7.0	20.8	55	2280	97	7.0
	85	19.5	48	2111	89	6.5	19.7	48	2151	90	6.5	19.9	49	2191	92	6.4
	80	18.8	43	2031	84	6.1	19.0	44	2070	86	6.0	19.2	45	2107	87	5.9
	75	18.3	39	1961	80	5.7	18.4	40	1996	81	5.6	18.6	41	2033	83	5.6
	70	18.0	37	1896	76	5.4	18.1	37	1932	77	5.3	18.2	38	1964	78	5.2
	65	17.7	34	1844	72	5.2	17.8	35	1879	74	5.1	18.0	36	1916	75	5.1
	60	17.5	33	1797	69	5.0	17.6	33	1831	70	4.9	17.7	34	1865	71	4.9
	55	17.4	31	1757	65	4.9	17.5	32	1785	66	4.8	17.6	32	1819	67	4.7
	50	17.3	30	1720	61	4.7	17.4	31	1753	62	4.7	17.5	31	1785	63	4.6
	45	17.4	29	1689	57	4.7	17.4	30	1721	58	4.6	17.5	30	1755	59	4.5
	40	17.5	30	1683	53	4.7	17.6	30	1709	54	4.6	17.7	31	1740	55	4.5
3500	105	23.8	75	2520	109	10.1	24.2	77	2568	111	10.0	24.6	78	2616	113	10.0
(47° F)	100	22.2	66	2401	103	8.8	22.6	67	2447	105	8.9	22.9	68	2492	107	8.9
(8° C)	95	21.1	59	2307	99	7.8	21.4	60	2349	101	7.9	21.7	61	2393	102	7.9
	90	20.2	53	2216	94	7.1	20.4	54	2257	96	7.1	20.6	55	2297	97	7.0
	85	19.4	48	2131	89	6.6	19.6	49	2172	91	6.5	19.8	50	2211	93	6.4
	80	18.7	43	2050	85	6.1	18.9	44	2089	86	6.0	19.1	45	2128	88	6.0
	75	18.1	40	1977	81	5.7	18.3	40	2014	82	5.6	18.5	41	2052	84	5.6
	70	17.8	37	1914	76	5.4	17.9	37	1947	78	5.3	18.1	38	1984	79	5.3
	65	17.6	35	1864	73	5.2	17.7	36	1899	74	5.1	17.8	36	1933	76	5.1
	60	17.3	33	1814	69	5.0	17.5	34	1849	71	4.9	17.6	34	1883	72	4.9
	55	17.2	31	1769	66	4.8	17.3	32	1803	67	4.8	17.4	33	1836	68	4.7
	50	17.1	30	1736	62	4.7	17.2	31	1770	63	4.7	17.4	31	1802	64	4.6
	45	17.2	30	1704	58	4.7	17.2	30	1740	59	4.6	17.3	31	1771	60	4.5
	40	17.3	30	1693	54	4.7	17.4	30	1725	55	4.6	17.5	31	1754	56	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 9 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D | Mixture: Leaned | Weight: 1760 lbs | Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172 | Carb Heat: OFF | Flaps: UP

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
4000 (45° F) (7° C)	105	22.5	71	2393	104	10.2	22.9	73	2443	106	10.2	23.3	75	2494	108	10.2
	100	21.1	63	2280	98	8.8	21.4	64	2327	100	8.8	21.8	65	2376	102	8.9
	95	20.1	56	2190	94	8.0	20.4	57	2237	96	7.9	20.7	58	2281	98	7.9
	90	19.3	50	2102	89	7.4	19.5	52	2148	91	7.3	19.8	53	2192	93	7.2
	85	18.6	46	2024	85	6.8	18.8	47	2067	87	6.7	19.0	48	2109	88	6.7
	80	18.0	41	1947	81	6.4	18.2	42	1987	82	6.3	18.4	43	2029	84	6.2
	75	17.5	38	1877	76	6.0	17.7	39	1917	78	5.9	17.9	39	1959	80	5.8
	70	17.2	35	1815	72	5.7	17.4	36	1855	74	5.6	17.5	36	1891	75	5.5
	65	17.0	33	1766	69	5.5	17.1	34	1804	71	5.4	17.3	35	1844	72	5.3
	60	16.9	32	1726	66	5.3	17.0	32	1759	67	5.2	17.1	33	1796	69	5.1
	55	16.7	30	1685	62	5.1	16.8	30	1720	64	5.0	16.9	31	1756	65	4.9
	50	16.8	29	1646	59	5.0	16.8	29	1681	60	4.9	16.9	30	1719	61	4.8
	45	16.7	28	1617	55	4.9	16.8	29	1651	56	4.8	16.9	29	1685	57	4.7
	40	16.8	28	1601	51	4.9	16.9	29	1644	52	4.8	17.0	29	1674	53	4.7
4500 (43° F) (6° C)	105	22.4	72	2415	105	10.3	22.8	74	2466	107	10.3	23.3	75	2518	109	10.3
	100	21.0	63	2301	99	8.9	21.3	64	2349	101	8.9	21.7	66	2399	103	9.0
	95	20.1	57	2211	95	8.1	20.3	58	2257	97	8.0	20.6	59	2303	99	8.0
	90	19.1	51	2120	90	7.4	19.4	52	2168	92	7.3	19.6	53	2211	94	7.2
	85	18.4	46	2040	86	6.8	18.7	47	2085	87	6.8	18.9	48	2129	89	6.7
	80	17.9	42	1967	81	6.4	18.0	43	2006	83	6.3	18.3	43	2048	85	6.2
	75	17.4	38	1897	77	6.0	17.5	39	1935	79	5.9	17.7	40	1977	80	5.8
	70	17.1	35	1832	73	5.7	17.2	36	1870	75	5.6	17.3	37	1908	76	5.5
	65	16.8	33	1784	70	5.5	17.0	34	1823	71	5.4	17.2	35	1861	73	5.3
	60	16.7	32	1743	66	5.3	16.8	32	1776	68	5.2	16.9	33	1813	69	5.1
	55	16.6	30	1699	63	5.1	16.7	31	1731	64	5.0	16.8	31	1768	65	4.9
	50	16.6	29	1663	59	5.0	16.6	30	1696	60	4.9	16.7	30	1731	62	4.8
	45	16.5	28	1636	55	4.9	16.6	29	1671	56	4.8	16.7	30	1706	58	4.7
	40	16.7	28	1616	51	4.9	16.8	29	1657	52	4.8	16.9	30	1691	54	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 10 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
4000 (45° F) (7° C)	105	23.7	76	2544	110	10.1	24.2	77	2592	112	10.1	24.6	79	2641	115	10.0
	100	22.2	66	2424	104	8.9	22.5	68	2470	106	8.9	22.9	69	2515	108	8.9
	95	21.0	59	2327	100	7.9	21.3	61	2371	101	8.0	21.6	62	2415	103	8.0
	90	20.1	54	2238	95	7.2	20.4	55	2281	97	7.2	20.6	55	2318	98	7.1
	85	19.3	48	2151	90	6.6	19.5	49	2192	92	6.5	19.7	50	2232	94	6.5
	80	18.6	44	2069	86	6.1	18.8	45	2109	87	6.0	19.0	46	2147	89	6.0
	75	18.0	40	1995	81	5.7	18.2	41	2034	83	5.7	18.4	42	2071	84	5.6
	70	17.6	37	1927	77	5.4	17.8	38	1964	78	5.3	17.9	38	2002	80	5.3
	65	17.4	35	1881	73	5.2	17.6	36	1916	75	5.1	17.6	36	1948	76	5.0
	60	17.2	33	1831	70	5.0	17.3	34	1867	71	4.9	17.5	35	1904	73	4.9
	55	17.1	32	1786	66	4.8	17.2	32	1820	67	4.8	17.3	33	1854	69	4.7
	50	17.0	31	1753	62	4.7	17.1	31	1786	63	4.7	17.2	32	1814	65	4.6
	45	17.0	30	1723	58	4.7	17.1	30	1755	59	4.6	17.2	31	1788	60	4.5
	40	17.2	30	1707	54	4.7	17.3	31	1739	55	4.6	17.3	31	1769	56	4.5
4500 (43° F) (6° C)	105	23.7	77	2567	111	10.2	24.2	78	2617	113	10.2					
	100	22.1	67	2446	105	9.0	22.5	68	2493	107	9.0	22.9	70	2539	109	9.0
	95	20.9	60	2348	101	8.0	21.2	61	2393	102	8.1	21.6	62	2438	104	8.1
	90	19.9	54	2254	96	7.2	20.2	55	2299	97	7.2	20.5	56	2340	99	7.2
	85	19.2	49	2171	91	6.6	19.4	50	2213	93	6.6	19.7	51	2253	94	6.5
	80	18.5	44	2089	86	6.1	18.7	45	2128	88	6.1	18.9	46	2167	90	6.0
	75	17.9	41	2014	82	5.7	18.1	41	2053	84	5.7	18.3	42	2090	85	5.6
	70	17.5	37	1945	78	5.4	17.6	38	1983	79	5.3	17.8	39	2019	81	5.3
	65	17.3	36	1897	74	5.2	17.4	36	1931	76	5.1	17.5	37	1968	77	5.1
	60	17.1	34	1852	71	5.0	17.2	34	1886	72	5.0	17.3	35	1920	73	4.9
	55	16.9	32	1802	67	4.8	17.0	33	1836	68	4.8	17.2	33	1871	69	4.7
	50	16.8	31	1765	63	4.7	16.9	31	1798	64	4.7	17.1	32	1831	65	4.6
	45	16.8	30	1740	59	4.7	17.0	31	1774	60	4.6	17.1	31	1806	61	4.5
	40	16.9	30	1721	55	4.6	17.0	31	1758	56	4.6	17.1	31	1789	57	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 11 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
5000 (41° F) (5° C)	105	22.3	72	2435	106	10.3	22.8	74	2490	108	10.4	23.2	76	2541	110	10.3
	100	21.0	64	2323	100	9.0	21.3	65	2372	102	9.1	21.7	66	2421	104	9.1
	95	19.9	57	2230	95	8.1	20.2	58	2277	97	8.1	20.5	59	2324	99	8.1
	90	19.0	51	2142	91	7.4	19.3	52	2187	93	7.3	19.6	53	2233	95	7.3
	85	18.4	47	2062	86	6.9	18.6	47	2105	88	6.8	18.8	48	2149	90	6.7
	80	17.7	42	1983	82	6.4	17.9	43	2025	84	6.3	18.1	44	2067	86	6.2
	75	17.3	39	1916	78	6.0	17.4	39	1954	80	5.9	17.6	40	1994	81	5.8
	70	16.9	36	1848	74	5.7	17.0	36	1887	75	5.6	17.2	37	1925	77	5.5
	65	16.7	34	1802	70	5.5	16.9	35	1841	72	5.4	16.9	35	1875	73	5.3
	60	16.5	32	1754	67	5.3	16.7	33	1796	69	5.2	16.8	33	1833	70	5.1
	55	16.4	30	1715	63	5.1	16.5	31	1747	65	5.0	16.6	32	1784	66	4.9
	50	16.4	29	1681	60	5.0	16.5	30	1711	61	4.9	16.6	31	1747	62	4.8
	45	16.4	29	1651	56	4.9	16.5	29	1688	57	4.8	16.6	30	1722	58	4.7
	40	16.5	29	1633	52	4.9	16.6	29	1668	53	4.8	16.7	30	1706	54	4.7
5500 (39° F) (4° C)	100	20.9	64	2345	101	9.1	21.2	66	2395	103	9.2	21.6	67	2444	105	9.2
	95	19.9	58	2252	96	8.2	20.1	59	2299	98	8.1	20.5	60	2346	100	8.2
	90	19.0	52	2162	92	7.4	19.2	53	2209	94	7.4	19.5	54	2254	96	7.3
	85	18.3	47	2081	87	6.9	18.5	48	2125	89	6.8	18.7	49	2169	91	6.7
	80	17.6	42	2001	83	6.4	17.8	43	2044	85	6.3	18.0	44	2086	86	6.2
	75	17.1	39	1931	79	6.0	17.3	40	1972	80	5.9	17.5	41	2013	82	5.9
	70	16.8	36	1865	74	5.7	16.9	37	1904	76	5.6	17.1	37	1944	78	5.5
	65	16.6	34	1818	71	5.5	16.7	34	1855	73	5.4	16.8	35	1892	74	5.3
	60	16.4	32	1773	68	5.3	16.5	33	1813	69	5.2	16.7	34	1850	71	5.1
	55	16.2	31	1727	64	5.1	16.4	31	1765	65	5.0	16.5	32	1801	67	4.9
	50	16.2	30	1697	60	5.0	16.3	30	1727	62	4.9	16.4	31	1763	63	4.8
	45	16.2	29	1667	56	4.9	16.3	30	1704	57	4.8	16.4	30	1740	59	4.8
	40	16.3	29	1653	52	4.9	16.4	30	1688	53	4.8	16.5	30	1722	55	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 12 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
5000	105	23.7	78	2592	112	10.3	24.1	79	2641	115	10.2					
(41° F)	100	22.1	68	2469	106	9.1	22.4	69	2516	108	9.1	22.8	70	2563	110	9.0
(5° C)	95	20.9	61	2370	101	8.1	21.2	62	2416	103	8.2	21.5	63	2461	105	8.2
	90	19.8	54	2276	97	7.2	20.1	55	2319	98	7.2	20.4	56	2362	100	7.3
	85	19.1	49	2191	92	6.6	19.3	50	2234	94	6.6	19.5	51	2272	95	6.6
	80	18.4	45	2108	87	6.2	18.6	46	2148	89	6.1	18.8	46	2188	90	6.0
	75	17.8	41	2034	83	5.8	18.0	42	2073	84	5.7	18.2	42	2110	86	5.6
	70	17.4	38	1964	78	5.4	17.5	38	2001	80	5.4	17.7	39	2039	81	5.3
	65	17.1	35	1912	75	5.2	17.2	36	1948	76	5.1	17.4	37	1986	78	5.1
	60	16.9	34	1869	71	5.0	17.1	35	1904	73	5.0	17.1	35	1935	74	4.9
	55	16.8	32	1819	67	4.9	16.9	33	1855	69	4.8	17.0	34	1892	70	4.7
	50	16.7	31	1781	63	4.7	16.8	32	1815	65	4.7	16.9	32	1850	66	4.6
	45	16.7	31	1757	59	4.7	16.8	31	1790	60	4.6	16.9	32	1818	62	4.5
	40	16.8	30	1739	55	4.6	16.9	31	1773	56	4.6	17.0	32	1807	57	4.5
5500	100	22.0	68	2492	107	9.2	22.4	70	2540	109	9.2	22.8	71	2587	111	9.1
(39° F)	95	20.8	61	2394	102	8.2	21.2	62	2440	104	8.3	21.5	64	2484	106	8.3
(4° C)	90	19.8	55	2297	97	7.3	20.0	56	2341	99	7.3	20.3	57	2384	101	7.4
	85	19.0	50	2214	93	6.7	19.3	51	2256	94	6.7	19.4	51	2293	96	6.6
	80	18.3	45	2128	88	6.2	18.5	46	2169	90	6.1	18.7	47	2211	91	6.1
	75	17.7	41	2053	84	5.8	17.9	42	2092	85	5.7	18.1	43	2130	87	5.7
	70	17.2	38	1984	79	5.4	17.4	39	2020	81	5.4	17.6	40	2058	82	5.3
	65	17.0	36	1932	76	5.2	17.1	36	1966	77	5.1	17.3	37	2002	78	5.1
	60	16.8	34	1886	72	5.0	16.9	35	1918	73	4.9	17.0	35	1955	75	4.9
	55	16.6	33	1840	68	4.9	16.8	33	1875	69	4.8	16.9	34	1909	71	4.7
	50	16.5	31	1798	64	4.7	16.7	32	1833	65	4.7	16.8	33	1870	66	4.6
	45	16.5	31	1768	60	4.7	16.6	31	1802	61	4.6	16.8	32	1835	62	4.5
	40	16.6	31	1756	56	4.7	16.8	31	1792	57	4.6	16.9	32	1824	58	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 13 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
6000	100	20.8	65	2367	102	9.2	21.2	66	2417	104	9.3	21.6	68	2467	106	9.3
(38° F)	95	19.8	58	2272	97	8.2	20.1	59	2321	99	8.2	20.4	61	2370	101	8.3
(3° C)	90	18.9	52	2184	92	7.5	19.1	53	2228	94	7.4	19.4	54	2274	96	7.4
	85	18.1	47	2099	88	6.9	18.4	48	2146	90	6.8	18.6	49	2190	92	6.8
	80	17.4	43	2019	84	6.4	17.7	44	2064	85	6.3	17.9	45	2106	87	6.3
	75	17.0	39	1951	79	6.0	17.2	40	1991	81	5.9	17.4	41	2032	83	5.9
	70	16.7	36	1884	75	5.7	16.8	37	1923	77	5.6	16.9	38	1964	78	5.5
	65	16.4	34	1835	72	5.5	16.5	35	1871	73	5.4	16.7	35	1910	75	5.3
	60	16.2	33	1791	68	5.3	16.3	33	1825	70	5.2	16.4	34	1863	71	5.1
	55	16.1	31	1743	65	5.1	16.3	32	1785	66	5.0	16.4	32	1818	67	4.9
	50	16.0	30	1707	61	5.0	16.2	30	1744	62	4.9	16.3	31	1780	63	4.8
	45	16.0	29	1680	57	4.9	16.2	30	1721	58	4.8	16.3	30	1750	59	4.7
	40	16.2	29	1669	53	4.9	16.2	30	1703	54	4.8	16.4	30	1738	55	4.7
6500	100	20.8	66	2390	103	9.4	21.1	67	2440	105	9.4	21.5	68	2491	107	9.4
(36° F)	95	19.7	59	2296	98	8.3	20.0	60	2343	100	8.3	20.4	61	2392	102	8.4
(2° C)	90	18.8	53	2202	93	7.5	19.0	54	2249	95	7.5	19.3	55	2296	97	7.4
	85	18.0	48	2119	89	6.9	18.2	48	2163	91	6.8	18.5	50	2208	93	6.8
	80	17.4	43	2040	84	6.5	17.6	44	2083	86	6.4	17.8	45	2127	88	6.3
	75	16.9	40	1969	80	6.1	17.1	41	2010	82	6.0	17.3	41	2052	84	5.9
	70	16.5	37	1900	76	5.7	16.6	37	1940	78	5.6	16.8	38	1982	79	5.5
	65	16.3	35	1849	72	5.5	16.4	35	1890	74	5.4	16.5	36	1928	76	5.3
	60	16.1	33	1808	69	5.3	16.2	33	1844	70	5.2	16.3	34	1883	72	5.1
	55	15.9	31	1761	65	5.1	16.1	32	1801	67	5.0	16.2	33	1839	68	5.0
	50	15.9	30	1723	61	5.0	16.0	31	1761	63	4.9	16.1	31	1798	64	4.8
	45	15.9	29	1694	57	4.9	16.0	30	1731	59	4.8	16.1	31	1768	60	4.7
	40	16.0	29	1677	53	4.9	16.1	30	1721	54	4.8	16.2	31	1757	56	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 14 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D
Propeller: McCauley TM7458/1C172
Mixture: Leaned
Carb Heat: OFF
Weight: 1760 lbs
Flaps: UP
Data Basis: *RPM* Model

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
6000	100	22.0	69	2516	108	9.3	22.4	70	2564	110	9.2	22.8	72	2613	112	9.2
(38° F)	95	20.8	62	2416	103	8.3	21.1	63	2463	105	8.4	21.5	64	2508	107	8.4
(3° C)	90	19.7	55	2319	98	7.4	20.0	56	2363	100	7.4	20.3	58	2407	102	7.5
	85	18.8	50	2231	94	6.7	19.1	51	2273	95	6.7	19.4	52	2315	97	6.7
	80	18.2	46	2148	89	6.2	18.4	47	2190	91	6.1	18.6	47	2230	92	6.1
	75	17.6	42	2073	84	5.8	17.8	43	2111	86	5.7	18.0	43	2151	88	5.7
	70	17.1	39	2002	80	5.5	17.3	39	2040	81	5.4	17.5	40	2078	83	5.3
	65	16.8	36	1950	76	5.2	17.0	37	1985	78	5.1	17.1	38	2022	79	5.1
	60	16.6	34	1900	73	5.0	16.7	35	1939	74	5.0	16.9	36	1971	75	4.9
	55	16.5	33	1857	69	4.9	16.6	34	1892	70	4.8	16.7	34	1923	71	4.7
	50	16.4	32	1816	65	4.7	16.5	32	1851	66	4.7	16.7	33	1888	67	4.6
	45	16.4	31	1785	60	4.7	16.5	32	1819	62	4.6	16.7	32	1857	63	4.5
	40	16.5	31	1775	56	4.7	16.6	32	1809	57	4.6	16.7	32	1842	58	4.5
6500	100	21.9	70	2540	109	9.4	22.4	71	2590	111	9.3					
(36° F)	95	20.7	62	2439	104	8.4	21.1	64	2486	106	8.4	21.4	65	2532	108	8.4
(2° C)	90	19.6	56	2341	99	7.5	19.9	57	2386	101	7.5	20.3	58	2430	103	7.6
	85	18.7	50	2252	94	6.7	19.0	51	2295	96	6.7	19.3	52	2337	98	6.8
	80	18.1	46	2169	90	6.2	18.3	47	2210	91	6.2	18.5	48	2248	93	6.1
	75	17.5	42	2092	85	5.8	17.7	43	2132	87	5.8	17.9	44	2172	88	5.7
	70	17.0	39	2021	81	5.5	17.2	40	2060	82	5.4	17.4	40	2098	84	5.4
	65	16.7	36	1966	77	5.2	16.9	37	2005	78	5.2	17.0	38	2041	80	5.1
	60	16.5	35	1918	73	5.0	16.6	35	1954	75	5.0	16.8	36	1990	76	4.9
	55	16.4	33	1874	69	4.9	16.4	34	1906	71	4.8	16.6	34	1944	72	4.7
	50	16.2	32	1832	65	4.7	16.3	32	1866	67	4.7	16.5	33	1904	68	4.6
	45	16.3	31	1802	61	4.7	16.4	32	1840	62	4.6	16.5	33	1873	63	4.5
	40	16.4	31	1792	57	4.7	16.5	32	1820	58	4.6	16.6	33	1854	59	4.5

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 15 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
7000 (34° F) (1° C)	100	20.6	66	2410	104	9.4	21.1	68	2464	106	9.5	21.5	69	2514	108	9.5
	95	19.6	59	2317	99	8.4	20.0	61	2366	101	8.4	20.3	62	2415	103	8.5
	90	18.7	53	2225	94	7.6	18.9	54	2270	96	7.5	19.3	55	2317	98	7.5
	85	17.9	48	2138	90	7.0	18.1	49	2184	92	6.9	18.4	50	2229	94	6.8
	80	17.3	44	2059	85	6.5	17.5	45	2104	87	6.4	17.7	46	2147	89	6.3
	75	16.8	40	1987	81	6.1	17.0	41	2029	83	6.0	17.2	42	2071	84	5.9
	70	16.3	37	1918	77	5.7	16.6	38	1960	78	5.6	16.7	39	2000	80	5.6
	65	16.2	35	1868	73	5.5	16.3	35	1907	75	5.4	16.4	36	1947	76	5.3
	60	16.0	33	1824	70	5.3	16.1	34	1861	71	5.2	16.2	34	1898	73	5.1
	55	15.8	32	1780	66	5.1	15.9	32	1817	67	5.0	16.0	33	1854	69	4.9
	50	15.7	30	1740	62	5.0	15.9	31	1781	63	4.9	16.0	32	1818	65	4.8
	45	15.7	30	1711	58	4.9	15.9	30	1747	59	4.8	16.0	31	1785	60	4.7
	40	15.8	30	1697	54	4.9	16.0	31	1738	55	4.8	16.1	31	1774	56	4.7
7500 (32° F) (0° C)	95	19.6	60	2339	100	8.5	19.9	61	2388	102	8.6	20.3	62	2438	104	8.6
	90	18.6	54	2247	95	7.6	18.9	55	2292	97	7.6	19.2	56	2339	99	7.6
	85	17.8	49	2162	91	7.0	18.1	49	2205	93	6.9	18.3	50	2250	94	6.9
	80	17.2	44	2078	86	6.5	17.4	45	2124	88	6.4	17.6	46	2165	90	6.3
	75	16.7	40	2007	82	6.1	16.9	41	2049	83	6.0	17.1	42	2091	85	5.9
	70	16.3	37	1940	77	5.7	16.4	38	1979	79	5.6	16.6	39	2020	81	5.6
	65	16.0	35	1887	74	5.5	16.1	36	1926	75	5.4	16.3	37	1966	77	5.3
	60	15.8	33	1838	70	5.3	15.9	34	1878	72	5.2	16.1	35	1916	73	5.1
	55	15.7	32	1797	66	5.1	15.8	32	1832	68	5.0	15.9	33	1872	69	4.9
	50	15.6	31	1759	63	5.0	15.8	32	1798	64	4.9	15.9	32	1835	65	4.8
	45	15.6	30	1727	58	4.9	15.7	31	1764	60	4.8	15.9	32	1805	61	4.8
	40	15.7	30	1714	54	4.9	15.8	31	1749	55	4.8	16.0	31	1786	57	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 16 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D — Mixture: Leaned — Weight: 1760 lbs — Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172 — Carb Heat: OFF — Flaps: UP

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
7000	100	21.9	70	2564	110	9.4										
(34° F)	95	20.7	63	2463	105	8.5	21.0	64	2510	107	8.5	21.4	66	2556	109	8.5
(1° C)	90	19.6	56	2363	100	7.6	19.9	58	2409	102	7.6	20.2	59	2454	104	7.6
	85	18.7	51	2273	95	6.8	18.9	52	2317	97	6.8	19.2	53	2359	99	6.8
	80	18.0	47	2192	91	6.3	18.2	48	2233	92	6.2	18.4	48	2270	94	6.2
	75	17.4	43	2112	86	5.8	17.6	43	2152	88	5.8	17.8	44	2192	89	5.7
	70	16.9	39	2040	81	5.5	17.1	40	2080	83	5.4	17.3	41	2117	85	5.4
	65	16.6	37	1986	78	5.2	16.8	38	2024	79	5.2	17.0	38	2062	81	5.1
	60	16.3	35	1939	74	5.0	16.5	36	1973	75	5.0	16.7	36	2010	77	4.9
	55	16.2	33	1891	70	4.9	16.3	34	1927	71	4.8	16.5	35	1962	73	4.7
	50	16.2	33	1854	66	4.8	16.2	33	1885	67	4.7	16.3	33	1921	68	4.6
	45	16.1	32	1820	62	4.7	16.3	32	1857	63	4.6	16.4	33	1891	64	4.6
	40	16.2	32	1803	57	4.7	16.4	32	1839	58	4.6	16.5	33	1876	59	4.6
7500	95	20.6	64	2486	106	8.6	21.0	65	2534	108	8.6	21.4	66	2582	110	8.5
(32° F)	90	19.5	57	2387	101	7.7	19.8	58	2432	103	7.7	20.2	59	2477	105	7.7
(0° C)	85	18.6	51	2295	96	6.9	18.9	52	2339	98	6.9	19.2	53	2382	100	6.9
	80	17.8	47	2208	91	6.3	18.1	48	2250	93	6.2	18.3	48	2291	95	6.2
	75	17.3	43	2133	87	5.9	17.5	44	2176	88	5.8	17.8	45	2215	90	5.8
	70	16.8	40	2060	82	5.5	17.0	40	2099	84	5.4	17.2	41	2138	85	5.4
	65	16.5	37	2005	78	5.3	16.7	38	2044	80	5.2	16.8	39	2081	81	5.1
	60	16.2	35	1955	75	5.0	16.4	36	1992	76	5.0	16.6	37	2029	78	4.9
	55	16.1	34	1909	71	4.9	16.2	34	1945	72	4.8	16.3	35	1981	73	4.8
	50	16.0	32	1868	67	4.7	16.1	33	1902	68	4.7	16.2	34	1937	69	4.6
	45	16.0	32	1840	62	4.7	16.1	33	1874	63	4.6	16.2	33	1905	64	4.5
	40	16.1	32	1821	58	4.7	16.2	33	1859	59	4.6	16.4	33	1893	60	4.6

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 17 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
8000 (30° F) (-1° C)	95	19.5	61	2362	101	8.6	19.9	62	2411	103	8.7	20.2	63	2462	105	8.7
	90	18.5	54	2267	96	7.7	18.8	55	2314	98	7.7	19.1	57	2363	100	7.7
	85	17.8	49	2179	91	7.0	18.0	50	2226	93	7.0	18.2	51	2272	95	6.9
	80	17.1	44	2098	87	6.5	17.3	45	2143	89	6.4	17.5	46	2186	90	6.3
	75	16.6	41	2026	82	6.1	16.8	42	2069	84	6.0	17.0	43	2111	86	5.9
	70	16.2	38	1958	78	5.8	16.3	39	1998	80	5.7	16.5	39	2039	81	5.6
	65	15.8	35	1902	75	5.5	16.0	36	1945	76	5.4	16.2	37	1985	78	5.3
	60	15.7	34	1857	71	5.3	15.8	34	1897	73	5.2	15.9	35	1935	74	5.1
	55	15.6	32	1814	67	5.1	15.6	33	1850	69	5.0	15.8	33	1887	70	4.9
	50	15.5	31	1778	63	5.0	15.5	31	1811	65	4.9	15.7	32	1851	66	4.8
	45	15.5	30	1744	59	4.9	15.6	31	1786	60	4.9	15.7	32	1822	62	4.8
	40	15.6	30	1731	55	4.9	15.7	31	1767	56	4.8	15.9	32	1807	57	4.8
8500 (29° F) (-2° C)	95	19.4	61	2382	102	8.7	19.8	62	2435	104	8.8	20.2	64	2485	106	8.8
	90	18.5	55	2289	97	7.8	18.8	56	2337	99	7.8	19.1	57	2386	101	7.8
	85	17.6	49	2201	92	7.1	17.9	50	2247	94	7.0	18.2	51	2294	96	7.0
	80	17.0	45	2120	88	6.5	17.2	46	2162	90	6.4	17.4	47	2207	91	6.4
	75	16.5	41	2045	83	6.1	16.7	42	2089	85	6.0	16.9	43	2132	87	6.0
	70	16.0	38	1977	79	5.8	16.2	39	2018	81	5.7	16.4	40	2059	82	5.6
	65	15.7	36	1922	75	5.5	15.9	37	1964	77	5.4	16.1	37	2005	78	5.4
	60	15.5	34	1876	72	5.3	15.7	35	1915	73	5.2	15.9	35	1955	75	5.1
	55	15.4	33	1830	68	5.1	15.5	33	1868	69	5.0	15.7	34	1905	71	5.0
	50	15.3	31	1794	64	5.0	15.4	32	1831	65	4.9	15.6	33	1869	66	4.8
	45	15.3	31	1763	60	4.9	15.4	31	1801	61	4.8	15.6	32	1838	62	4.8
	40	15.4	31	1747	55	4.9	15.6	32	1788	57	4.8	15.7	32	1824	58	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 18 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
8000 (30° F) (-1° C)	95	20.6	64	2510	107	8.7	21.0	66	2559	109	8.6	21.3	67	2605	111	8.6
	90	19.5	58	2410	102	7.8	19.8	59	2456	104	7.8	20.1	60	2501	106	7.8
	85	18.5	52	2317	97	6.9	18.8	53	2362	99	7.0	19.1	54	2406	101	7.0
	80	17.7	47	2229	92	6.3	18.0	48	2272	94	6.3	18.3	49	2314	96	6.3
	75	17.2	43	2153	88	5.9	17.4	44	2192	89	5.8	17.6	45	2232	91	5.8
	70	16.7	40	2080	83	5.5	16.9	41	2120	85	5.5	17.1	42	2162	86	5.4
	65	16.4	38	2024	79	5.3	16.6	38	2063	81	5.2	16.7	39	2101	82	5.2
	60	16.1	36	1974	75	5.1	16.3	36	2012	77	5.0	16.5	37	2049	78	5.0
	55	15.9	34	1927	71	4.9	16.1	35	1965	73	4.8	16.2	35	1998	74	4.8
	50	15.8	33	1885	67	4.7	16.0	33	1924	68	4.7	16.1	34	1959	70	4.6
	45	15.9	32	1857	63	4.7	16.0	33	1889	64	4.6	16.1	33	1927	65	4.6
	40	16.0	32	1842	58	4.7	16.1	33	1876	59	4.6	16.2	33	1907	60	4.5
8500 (29° F) (-2° C)	95	20.6	65	2536	108	8.8	20.9	66	2582	110	8.7					
	90	19.4	58	2433	103	7.9	19.7	59	2479	105	7.9	20.1	60	2525	107	7.9
	85	18.5	52	2339	98	7.0	18.8	54	2385	100	7.1	19.1	55	2429	102	7.1
	80	17.7	48	2251	93	6.4	17.9	48	2293	95	6.3	18.2	49	2336	97	6.4
	75	17.1	44	2172	88	5.9	17.3	44	2212	90	5.8	17.5	45	2254	92	5.8
	70	16.6	40	2100	84	5.6	16.9	41	2143	85	5.5	17.1	42	2182	87	5.5
	65	16.3	38	2044	80	5.3	16.5	39	2083	82	5.2	16.7	40	2121	83	5.2
	60	16.0	36	1993	76	5.1	16.2	37	2032	78	5.0	16.4	37	2069	79	5.0
	55	15.8	34	1947	72	4.9	16.0	35	1981	73	4.8	16.1	36	2017	75	4.8
	50	15.7	33	1906	68	4.8	15.9	34	1943	69	4.7	16.0	34	1975	70	4.6
	45	15.7	32	1874	63	4.7	15.8	33	1910	65	4.6	16.0	34	1945	66	4.6
	40	15.9	33	1859	59	4.7	15.9	33	1891	60	4.6	16.1	34	1929	61	4.6

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 19 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
9000 (27° F) (-3° C)	95	19.4	62	2407	103	8.9	19.8	63	2458	105	8.9	20.2	64	2510	107	8.9
	90	18.4	55	2311	98	7.8	18.7	56	2360	100	7.9	19.0	58	2409	102	7.9
	85	17.6	50	2225	93	7.1	17.8	51	2269	95	7.1	18.1	52	2316	97	7.1
	80	16.9	45	2141	88	6.6	17.1	46	2183	90	6.5	17.3	47	2228	92	6.4
	75	16.4	42	2064	84	6.1	16.6	43	2109	86	6.1	16.7	43	2150	88	6.0
	70	15.9	38	1992	80	5.8	16.1	39	2037	81	5.7	16.3	40	2079	83	5.6
	65	15.7	36	1943	76	5.5	15.8	37	1983	78	5.4	16.0	38	2024	79	5.4
	60	15.4	34	1896	72	5.3	15.6	35	1934	74	5.2	15.7	36	1974	75	5.2
	55	15.3	33	1846	68	5.1	15.4	33	1885	70	5.0	15.5	34	1923	71	5.0
	50	15.2	32	1812	64	5.0	15.3	32	1847	66	4.9	15.4	33	1887	67	4.8
	45	15.1	31	1777	60	4.9	15.3	32	1818	61	4.8	15.4	32	1855	63	4.8
	40	15.3	31	1766	56	4.9	15.4	32	1803	57	4.8	15.5	32	1837	58	4.7
9500 (25° F) (-4° C)	90	18.3	56	2334	99	7.9	18.7	57	2383	101	8.0	19.0	58	2432	103	8.0
	85	17.5	51	2246	94	7.2	17.8	51	2291	96	7.1	18.1	53	2340	98	7.2
	80	16.8	46	2158	89	6.6	17.0	47	2205	91	6.5	17.3	48	2250	93	6.5
	75	16.2	42	2083	85	6.2	16.4	43	2127	87	6.1	16.7	44	2171	88	6.0
	70	15.8	39	2014	80	5.8	16.0	40	2057	82	5.7	16.3	41	2102	84	5.7
	65	15.5	37	1962	77	5.5	15.7	37	2002	78	5.5	15.9	38	2043	80	5.4
	60	15.3	34	1911	73	5.3	15.5	35	1952	75	5.2	15.6	36	1993	76	5.2
	55	15.1	33	1866	69	5.1	15.3	34	1907	71	5.1	15.4	34	1943	72	5.0
	50	15.1	32	1825	65	5.0	15.2	32	1865	66	4.9	15.3	33	1902	68	4.8
	45	15.1	31	1796	61	4.9	15.2	32	1833	62	4.8	15.3	33	1874	63	4.8
	40	15.1	31	1783	56	4.9	15.3	32	1820	58	4.8	15.4	32	1858	59	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 20 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D | Mixture: Leaned | Weight: 1760 lbs | Data Basis: *RPM* Model

Propeller: McCauley TM7458/1C172 | Carb Heat: OFF | Flaps: UP

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
9000 (27° F) (-3° C)	95	20.5	66	2558	109	8.8										
	90	19.4	59	2456	104	8.0	19.7	60	2504	106	8.0	20.1	61	2551	108	7.9
	85	18.4	53	2363	99	7.1	18.7	54	2408	101	7.2	19.0	55	2452	103	7.2
	80	17.6	48	2273	94	6.4	17.9	49	2316	96	6.4	18.1	50	2359	98	6.5
	75	17.0	44	2192	89	5.9	17.2	45	2234	91	5.9	17.4	46	2276	93	5.9
	70	16.5	41	2121	85	5.6	16.8	42	2163	86	5.5	17.0	43	2202	88	5.5
	65	16.2	38	2064	81	5.3	16.4	39	2104	82	5.3	16.6	40	2142	84	5.2
	60	15.9	36	2013	77	5.1	16.1	37	2052	78	5.0	16.3	38	2089	80	5.0
	55	15.7	35	1963	73	4.9	15.9	35	2001	74	4.9	16.0	36	2037	75	4.8
	50	15.6	34	1925	68	4.8	15.7	34	1962	70	4.7	15.9	35	1994	71	4.7
	45	15.6	33	1892	64	4.7	15.7	33	1928	65	4.6	15.9	34	1964	66	4.6
	40	15.7	33	1876	59	4.7	15.8	33	1912	61	4.6	16.0	34	1947	62	4.6
9500 (25° F) (-4° C)	90	19.3	59	2481	105	8.1	19.7	61	2529	107	8.0	20.0	62	2575	109	8.0
	85	18.4	54	2386	100	7.2	18.7	55	2432	102	7.3	19.0	56	2476	104	7.3
	80	17.5	49	2295	95	6.5	17.8	49	2338	97	6.5	18.1	50	2382	99	6.6
	75	16.9	44	2214	90	6.0	17.1	45	2256	92	5.9	17.4	46	2298	94	5.9
	70	16.5	41	2143	85	5.6	16.7	42	2184	87	5.6	16.8	43	2220	89	5.5
	65	16.1	39	2084	82	5.3	16.3	40	2127	83	5.3	16.5	40	2165	85	5.2
	60	15.8	37	2033	78	5.1	16.0	38	2072	79	5.1	16.2	38	2110	81	5.0
	55	15.6	35	1982	73	4.9	15.8	36	2020	75	4.9	15.9	36	2057	76	4.8
	50	15.5	34	1940	69	4.8	15.6	34	1978	70	4.7	15.8	35	2015	72	4.7
	45	15.5	33	1911	65	4.7	15.6	34	1947	66	4.6	15.8	34	1980	67	4.6
	40	15.6	33	1895	60	4.7	15.7	34	1931	61	4.6	15.9	34	1963	62	4.6

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 21 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
10000 (23° F) (-5° C)	90	18.2	56	2354	100	8.0	18.6	58	2406	102	8.1	19.0	59	2456	104	8.1
	85	17.4	51	2266	95	7.2	17.7	52	2315	97	7.2	18.0	53	2362	99	7.3
	80	16.7	46	2180	90	6.6	16.9	47	2226	92	6.6	17.2	48	2272	94	6.5
	75	16.2	42	2105	86	6.2	16.3	43	2147	87	6.1	16.6	44	2192	89	6.0
	70	15.7	39	2033	81	5.8	15.9	40	2077	83	5.7	16.2	41	2122	85	5.7
	65	15.4	37	1981	77	5.6	15.6	38	2022	79	5.5	15.8	39	2064	81	5.4
	60	15.2	35	1932	74	5.3	15.4	36	1971	75	5.3	15.5	37	2013	77	5.2
	55	14.9	33	1876	70	5.1	15.2	34	1923	71	5.1	15.3	35	1963	73	5.0
	50	15.0	32	1845	66	5.0	15.1	33	1883	67	4.9	15.2	34	1922	68	4.9
	45	14.9	32	1814	61	4.9	15.0	32	1851	63	4.8	15.2	33	1893	64	4.8
	40	15.0	31	1798	57	4.9	15.1	32	1839	58	4.8	15.3	33	1876	59	4.8
10500 (22° F) (-6° C)	90	18.2	57	2379	101	8.2	18.6	58	2430	103	8.2	18.9	60	2481	105	8.2
	85	17.4	52	2289	96	7.3	17.7	53	2337	98	7.3	18.0	54	2386	100	7.4
	80	16.7	47	2204	91	6.7	16.9	48	2248	93	6.6	17.1	49	2294	95	6.6
	75	16.1	43	2125	86	6.2	16.3	44	2168	88	6.1	16.5	44	2213	90	6.1
	70	15.6	39	2050	82	5.8	15.8	40	2095	84	5.7	16.0	41	2138	85	5.7
	65	15.3	37	1997	78	5.6	15.6	38	2044	80	5.5	15.7	39	2084	82	5.4
	60	15.1	35	1951	74	5.4	15.3	36	1991	76	5.3	15.4	37	2033	78	5.2
	55	14.9	34	1901	70	5.1	15.1	34	1942	72	5.1	15.2	35	1982	73	5.0
	50	14.8	32	1863	66	5.0	15.0	33	1901	68	4.9	15.1	34	1941	69	4.9
	45	14.8	32	1832	62	4.9	14.9	32	1869	63	4.8	15.1	33	1911	65	4.8
	40	14.9	32	1817	58	4.9	15.0	32	1853	59	4.8	15.2	33	1895	60	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 22 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	KIAS	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
10000 (23° F) (-5° C)	90	19.3	60	2506	106	8.1	19.6	61	2552	108	8.1					
	85	18.3	54	2409	101	7.3	18.6	55	2455	103	7.3	18.9	56	2501	105	7.4
	80	17.5	49	2317	96	6.5	17.8	50	2362	98	6.6	18.0	51	2406	99	6.6
	75	16.8	45	2235	91	6.0	17.1	46	2278	93	6.0	17.3	47	2320	95	6.0
	70	16.4	42	2160	86	5.6	16.5	42	2202	88	5.6	16.7	43	2241	90	5.5
	65	16.0	39	2107	82	5.4	16.2	40	2147	84	5.3	16.4	41	2186	85	5.3
	60	15.7	37	2053	78	5.1	15.9	38	2092	80	5.1	16.1	39	2133	81	5.0
	55	15.5	35	2002	74	4.9	15.7	36	2040	76	4.9	15.9	37	2077	77	4.8
	50	15.4	34	1960	70	4.8	15.5	35	1998	71	4.7	15.7	35	2034	72	4.7
	45	15.3	33	1929	65	4.7	15.5	34	1964	66	4.7	15.7	35	2000	68	4.6
	40	15.4	34	1914	61	4.7	15.6	34	1947	62	4.6	15.8	35	1983	63	4.6
10500 (22° F) (-6° C)	90	19.3	61	2528	107	8.2										
	85	18.3	55	2433	102	7.4	18.6	56	2480	104	7.4	18.9	57	2526	106	7.4
	80	17.4	50	2341	97	6.6	17.7	51	2386	99	6.7	18.0	52	2429	100	6.7
	75	16.7	45	2257	92	6.0	17.0	46	2300	94	6.0	17.3	47	2344	95	6.1
	70	16.2	42	2180	87	5.6	16.4	43	2222	89	5.6	16.7	43	2263	90	5.6
	65	15.9	40	2127	83	5.4	16.1	41	2167	85	5.3	16.3	41	2204	86	5.3
	60	15.6	38	2073	79	5.2	15.9	38	2115	81	5.1	16.0	39	2154	82	5.1
	55	15.4	36	2021	75	5.0	15.6	36	2060	76	4.9	15.8	37	2101	78	4.9
	50	15.3	35	1979	70	4.8	15.4	35	2017	72	4.8	15.6	36	2054	73	4.7
	45	15.2	34	1946	66	4.7	15.4	34	1983	67	4.7	15.6	35	2019	68	4.6
	40	15.3	34	1930	61	4.7	15.5	35	1967	62	4.7	15.7	35	2003	63	4.6

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 23 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
11000 (20° F) (-7° C)	85	17.3	52	2311	97	7.4	17.6	53	2360	99	7.4	17.9	54	2409	101	7.5
	80	16.6	47	2225	92	6.7	16.8	48	2271	94	6.7	17.1	49	2318	96	6.7
	75	16.0	43	2144	87	6.2	16.2	44	2190	89	6.2	16.4	45	2235	91	6.1
	70	15.5	40	2073	83	5.9	15.7	41	2116	84	5.8	15.9	41	2159	86	5.7
	65	15.2	38	2019	79	5.6	15.5	39	2065	81	5.5	15.7	39	2107	82	5.5
	60	15.0	36	1970	75	5.4	15.2	36	2011	77	5.3	15.3	37	2052	78	5.2
	55	14.7	34	1918	71	5.1	15.0	35	1961	73	5.1	15.1	35	2001	74	5.0
	50	14.7	33	1879	67	5.0	14.9	34	1921	68	5.0	15.0	34	1960	70	4.9
	45	14.7	32	1849	63	4.9	14.8	33	1887	64	4.9	15.0	33	1927	65	4.8
	40	14.8	32	1834	58	4.9	14.9	33	1875	59	4.9	15.1	33	1910	61	4.8
11500 (18° F) (-8° C)	85	17.2	52	2331	98	7.4	17.6	54	2384	100	7.5	17.9	55	2433	102	7.6
	80	16.5	48	2244	93	6.8	16.8	49	2293	95	6.7	17.0	50	2341	97	6.8
	75	15.9	44	2168	88	6.3	16.1	44	2211	90	6.2	16.4	45	2257	92	6.2
	70	15.4	40	2092	84	5.9	15.6	41	2136	85	5.8	15.8	42	2180	87	5.7
	65	15.1	38	2039	80	5.6	15.3	39	2080	81	5.5	15.5	39	2122	83	5.5
	60	14.9	36	1987	76	5.4	15.1	37	2034	78	5.3	15.3	38	2075	79	5.3
	55	14.7	34	1942	72	5.2	14.9	35	1981	73	5.1	15.0	36	2022	75	5.1
	50	14.5	33	1897	68	5.0	14.8	34	1940	69	5.0	14.9	35	1979	70	4.9
	45	14.6	32	1868	63	5.0	14.7	33	1907	64	4.9	14.9	34	1946	66	4.8
	40	14.7	33	1852	59	5.0	14.8	33	1891	60	4.9	15.0	34	1930	61	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 24 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
11000	85	18.2	55	2457	103	7.5	18.5	56	2503	105	7.5					
(20° F)	80	17.4	50	2364	98	6.7	17.7	51	2409	100	6.8	17.9	52	2453	101	6.8
(-7° C)	75	16.7	46	2279	93	6.1	16.9	47	2324	95	6.1	17.2	48	2367	96	6.2
	70	16.1	42	2202	88	5.7	16.4	43	2244	90	5.6	16.6	44	2286	91	5.6
	65	15.8	40	2144	84	5.4	16.0	41	2184	86	5.3	16.2	41	2225	87	5.3
	60	15.6	38	2096	80	5.2	15.8	39	2135	81	5.1	15.9	39	2170	83	5.1
	55	15.3	36	2042	76	5.0	15.5	37	2084	77	4.9	15.7	38	2121	78	4.9
	50	15.2	35	1999	71	4.8	15.4	36	2037	73	4.8	15.5	36	2075	74	4.7
	45	15.1	34	1965	66	4.7	15.3	35	2003	68	4.7	15.5	35	2040	69	4.6
	40	15.2	34	1949	62	4.7	15.4	35	1987	63	4.7	15.6	36	2023	64	4.6
11500	85	18.2	56	2483	104	7.6										
(18° F)	80	17.3	51	2387	99	6.8	17.6	52	2433	101	6.9	17.9	53	2480	102	6.9
(-8° C)	75	16.6	46	2303	94	6.2	16.9	47	2347	96	6.2	17.2	48	2390	97	6.3
	70	16.1	43	2224	89	5.7	16.3	44	2266	90	5.7	16.5	44	2307	92	5.7
	65	15.7	40	2164	85	5.4	15.9	41	2206	86	5.4	16.1	42	2247	88	5.3
	60	15.5	38	2116	81	5.2	15.6	39	2152	82	5.1	15.8	40	2191	84	5.1
	55	15.3	37	2065	76	5.0	15.4	37	2104	78	5.0	15.6	38	2142	79	4.9
	50	15.1	35	2019	72	4.9	15.3	36	2061	73	4.8	15.5	37	2099	75	4.8
	45	15.1	35	1985	67	4.8	15.2	35	2023	68	4.7	15.4	36	2064	70	4.7
	40	15.2	35	1968	62	4.8	15.3	35	2006	64	4.7	15.5	36	2047	65	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 25 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
12000	85	17.2	53	2357	99	7.6	17.5	54	2407	101	7.6	17.9	55	2459	103	7.7
(16° F)	80	16.4	48	2268	94	6.8	16.7	49	2316	96	6.8	17.0	50	2364	98	6.9
(-9° C)	75	15.8	44	2187	89	6.3	16.0	45	2233	91	6.2	16.3	46	2281	93	6.2
	70	15.4	41	2116	84	5.9	15.5	41	2158	86	5.8	15.8	42	2202	88	5.8
	65	15.0	38	2057	81	5.6	15.2	39	2101	82	5.5	15.4	40	2144	84	5.5
	60	14.8	37	2009	77	5.4	15.0	37	2054	78	5.4	15.1	38	2091	80	5.2
	55	14.6	35	1960	72	5.2	14.8	35	2001	74	5.1	15.0	36	2045	76	5.1
	50	14.4	33	1917	68	5.0	14.6	34	1959	70	5.0	14.8	35	1999	71	4.9
	45	14.4	32	1882	64	4.9	14.6	34	1926	65	4.9	14.8	34	1966	66	4.8
	40	14.6	33	1870	59	5.0	14.7	34	1910	61	4.9	14.9	34	1950	62	4.8
12500	80	16.4	49	2291	95	6.9	16.6	50	2339	97	6.9	16.9	51	2388	99	7.0
(14° F)	75	15.8	44	2209	90	6.3	16.0	45	2257	92	6.3	16.3	46	2303	94	6.3
(-10° C)	70	15.2	41	2133	85	5.9	15.5	42	2179	87	5.8	15.7	43	2224	89	5.8
	65	14.9	39	2079	81	5.6	15.1	39	2121	83	5.6	15.3	40	2165	85	5.5
	60	14.7	37	2028	77	5.4	14.8	37	2069	79	5.3	15.0	38	2111	81	5.3
	55	14.5	35	1977	73	5.2	14.6	36	2018	75	5.1	14.8	36	2059	76	5.1
	50	14.4	34	1939	69	5.1	14.6	35	1982	70	5.0	14.7	35	2019	72	4.9
	45	14.3	33	1903	64	5.0	14.5	34	1945	66	4.9	14.7	35	1986	67	4.8
	40	14.4	33	1889	60	5.0	14.6	34	1929	61	4.9	14.8	35	1969	62	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 26 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
12000	85															
(16° F)	80	17.3	51	2411	100	6.9	17.6	52	2459	102	7.0	17.9	53	2504	103	7.0
(-9° C)	75	16.6	47	2326	95	6.3	16.8	48	2371	96	6.3	17.1	49	2414	98	6.3
	70	16.0	43	2246	90	5.7	16.3	44	2290	91	5.7	16.5	45	2332	93	5.8
	65	15.6	41	2186	86	5.4	15.8	41	2228	87	5.4	16.1	42	2269	89	5.4
	60	15.3	38	2132	82	5.2	15.5	39	2173	83	5.1	15.7	40	2213	85	5.1
	55	15.2	37	2085	77	5.0	15.3	37	2120	79	4.9	15.5	38	2158	80	4.9
	50	15.0	36	2042	73	4.9	15.2	36	2081	74	4.8	15.4	37	2119	75	4.8
	45	15.0	35	2005	68	4.8	15.2	36	2046	69	4.7	15.3	36	2084	70	4.7
	40	15.1	35	1988	63	4.8	15.3	36	2029	64	4.7	15.4	36	2066	65	4.7
12500	80	17.3	52	2437	101	7.0	17.5	53	2483	103	7.0					
(14° F)	75	16.5	47	2349	96	6.3	16.8	48	2394	97	6.4	17.1	49	2438	99	6.4
(-10° C)	70	16.0	44	2269	91	5.8	16.2	45	2313	92	5.8	16.4	45	2355	94	5.8
	65	15.5	41	2208	86	5.5	15.8	42	2250	88	5.5	16.0	43	2293	90	5.4
	60	15.2	39	2153	82	5.2	15.4	40	2194	84	5.2	15.7	40	2235	85	5.2
	55	15.0	37	2101	78	5.0	15.2	38	2140	79	5.0	15.4	38	2180	81	4.9
	50	14.9	36	2062	73	4.9	15.1	37	2101	75	4.9	15.2	37	2135	76	4.8
	45	14.9	35	2028	68	4.8	15.1	36	2066	70	4.8	15.2	37	2103	71	4.7
	40	15.0	35	2011	64	4.8	15.2	36	2049	65	4.7	15.3	36	2082	66	4.7

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 27 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
13000	80	16.3	49	2310	96	6.9	16.6	50	2362	98	7.0	16.9	51	2413	100	7.1
(13° F)	75	15.7	45	2234	91	6.4	15.9	46	2279	93	6.4	16.2	47	2326	95	6.4
(-11° C)	70	15.2	42	2154	86	6.0	15.4	42	2201	88	5.9	15.7	43	2247	90	5.9
	65	14.9	39	2100	82	5.7	15.0	40	2143	84	5.6	15.3	41	2187	86	5.5
	60	14.6	37	2048	78	5.4	14.8	38	2090	80	5.4	15.0	38	2132	82	5.3
	55	14.4	36	1999	74	5.2	14.5	36	2038	76	5.1	14.7	37	2080	77	5.1
	50	14.2	34	1954	70	5.1	14.4	35	1996	71	5.0	14.6	35	2037	73	4.9
	45	14.2	33	1924	65	5.0	14.5	34	1968	66	4.9	14.6	35	2008	68	4.9
	40	14.3	33	1908	60	5.0	14.5	34	1951	62	4.9	14.7	35	1992	63	4.9
13500	80	16.2	49	2335	97	7.0	16.5	51	2385	99	7.1	16.9	52	2436	101	7.2
(11° F)	75	15.6	45	2252	92	6.4	15.9	46	2302	94	6.4	16.2	47	2350	96	6.5
(-12° C)	70	15.1	42	2176	87	6.0	15.4	43	2224	89	5.9	15.6	44	2270	91	5.9
	65	14.8	40	2122	83	5.7	15.0	40	2164	85	5.6	15.2	41	2209	86	5.6
	60	14.5	37	2069	79	5.5	14.7	38	2110	81	5.4	14.9	39	2154	82	5.3
	55	14.3	36	2015	75	5.2	14.5	36	2059	76	5.2	14.6	37	2101	78	5.1
	50	14.2	34	1977	70	5.1	14.3	35	2016	72	5.0	14.5	36	2058	73	5.0
	45	14.2	34	1946	66	5.0	14.4	35	1987	67	5.0	14.5	35	2028	68	4.9
	40	14.2	34	1921	61	5.0	14.4	34	1966	62	4.9	14.6	35	2006	64	4.9
14000	75	15.5	46	2274	93	6.5	15.8	47	2326	95	6.5	16.2	48	2376	97	6.6
(9° F)	70	15.1	42	2201	88	6.0	15.3	43	2246	90	6.0	15.5	44	2293	91	6.0
(-13° C)	65	14.7	40	2143	84	5.7	14.9	41	2186	86	5.7	15.1	42	2232	87	5.6
	60	14.4	38	2087	80	5.5	14.6	39	2132	81	5.4	14.8	39	2176	83	5.4
	55	14.2	36	2038	75	5.3	14.4	37	2079	77	5.2	14.6	37	2122	79	5.1
	50	14.1	35	1997	71	5.1	14.2	35	2036	73	5.0	14.4	36	2078	74	5.0
	45	14.0	34	1963	66	5.0	14.2	35	2002	68	4.9	14.4	35	2043	69	4.9
	40	14.1	34	1948	62	5.0	14.3	35	1988	63	4.9	14.5	35	2026	64	4.9
14500	75	15.5	46	2299	94	6.5	15.8	48	2351	96	6.6	16.1	48	2399	98	6.7
(7° F)	70	14.9	42	2218	89	6.0	15.2	44	2270	91	6.0	15.5	45	2316	92	6.1
(-14° C)	65	14.6	40	2165	85	5.8	14.9	41	2209	86	5.7	15.1	42	2255	88	5.7
	60	14.3	38	2110	81	5.5	14.5	39	2153	82	5.4	14.8	40	2199	84	5.4
	55	14.1	36	2059	76	5.3	14.3	37	2100	78	5.2	14.5	38	2143	79	5.2
	50	14.0	35	2018	72	5.1	14.1	36	2057	73	5.1	14.3	36	2099	75	5.0
	45	14.0	35	1984	67	5.1	14.1	35	2022	68	5.0	14.3	36	2064	70	4.9
	40	14.0	34	1965	62	5.0	14.2	35	2005	64	4.9	14.4	36	2047	65	4.9

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 28 of 30)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D | Mixture: Leaned | Weight: 1760 lbs | Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172 | Carb Heat: OFF | Flaps: UP

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
13000	80	17.2	52	2460	102	7.1										
(13° F)	75	16.5	48	2373	97	6.4	16.8	49	2418	98	6.5	17.0	50	2463	100	6.5
(-11° C)	70	15.9	44	2292	91	5.9	16.1	45	2336	93	5.9	16.4	46	2379	95	5.9
	65	15.5	41	2230	87	5.5	15.7	42	2274	89	5.5	16.0	43	2316	91	5.5
	60	15.2	39	2175	83	5.2	15.4	40	2217	85	5.2	15.6	41	2257	86	5.2
	55	14.9	37	2122	79	5.0	15.1	38	2162	80	5.0	15.3	39	2202	82	5.0
	50	14.8	36	2077	74	4.9	15.0	37	2117	75	4.8	15.1	37	2156	77	4.8
	45	14.8	36	2047	69	4.8	14.9	36	2082	70	4.7	15.1	37	2120	72	4.7
	40	14.9	36	2030	64	4.8	15.0	36	2065	65	4.7	15.2	37	2102	67	4.7
13500	80															
(11° F)	75	16.5	48	2399	98	6.5	16.7	49	2443	99	6.6					
(-12° C)	70	15.8	45	2315	92	5.9	16.1	45	2360	94	6.0	16.4	46	2403	96	6.0
	65	15.4	42	2254	88	5.6	15.7	43	2297	90	5.6	15.9	44	2339	91	5.6
	60	15.1	40	2197	84	5.3	15.3	40	2239	86	5.3	15.5	41	2281	87	5.3
	55	14.8	38	2143	79	5.1	15.0	39	2183	81	5.0	15.3	39	2224	82	5.0
	50	14.7	36	2098	75	4.9	14.9	37	2138	76	4.9	15.1	38	2178	78	4.8
	45	14.7	36	2064	70	4.8	14.8	36	2102	71	4.8	15.0	37	2141	72	4.7
	40	14.8	36	2049	65	4.8	14.9	37	2088	66	4.8	15.1	37	2123	67	4.7
14000	75	16.4	49	2423	98	6.6										
(9° F)	70	15.8	45	2339	93	6.0	16.1	46	2386	95	6.1	16.3	47	2429	97	6.1
(-13° C)	65	15.4	42	2277	89	5.6	15.6	43	2320	91	5.6	15.9	44	2363	92	5.7
	60	15.0	40	2219	85	5.3	15.3	41	2263	86	5.3	15.5	42	2304	88	5.3
	55	14.8	38	2164	80	5.1	15.0	39	2206	82	5.1	15.2	40	2248	83	5.1
	50	14.6	37	2119	75	4.9	14.8	38	2160	77	4.9	15.0	38	2200	78	4.9
	45	14.6	36	2084	71	4.8	14.8	37	2124	72	4.8	15.0	37	2163	73	4.8
	40	14.7	36	2066	66	4.8	14.8	37	2106	67	4.8	15.0	38	2145	68	4.7
14500	75															
(7° F)	70	15.8	46	2365	94	6.1	16.0	46	2408	96	6.2					
(-14° C)	65	15.3	43	2300	90	5.7	15.6	44	2344	92	5.7	15.9	45	2389	93	5.8
	60	15.0	41	2243	86	5.4	15.2	41	2286	87	5.4	15.4	42	2328	89	5.4
	55	14.7	39	2186	81	5.1	14.9	39	2230	83	5.1	15.2	40	2271	84	5.1
	50	14.5	37	2141	76	5.0	14.7	38	2182	78	4.9	15.0	39	2224	79	4.9
	45	14.5	36	2105	71	4.9	14.7	37	2145	73	4.8	14.9	38	2185	74	4.8
	40	14.6	36	2087	66	4.8	14.8	37	2127	67	4.8	15.0	38	2167	69	4.8

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 29 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
15000 (5° F) (-15° C)	70	14.9	43	2241	90	6.1	15.2	44	2292	91	6.1	15.5	45	2342	93	6.2
	65	14.5	41	2185	85	5.8	14.8	42	2232	87	5.7	15.0	42	2278	89	5.7
	60	14.3	39	2131	81	5.5	14.5	39	2177	83	5.5	14.7	40	2222	85	5.4
	55	14.1	37	2082	77	5.3	14.2	37	2122	79	5.2	14.5	38	2167	80	5.2
	50	13.9	36	2038	72	5.2	14.1	36	2078	74	5.1	14.3	37	2120	76	5.0
	45	13.9	35	2005	68	5.1	14.0	35	2043	69	5.0	14.2	36	2085	71	4.9
	40	14.0	35	1987	63	5.1	14.1	35	2026	64	5.0	14.3	36	2068	66	4.9
15500 (4° F) (-16° C)	70	14.8	43	2263	90	6.1	15.2	45	2317	92	6.2	15.4	46	2365	94	6.2
	65	14.4	41	2204	86	5.8	14.7	42	2255	88	5.8	15.0	43	2301	90	5.8
	60	14.2	39	2153	82	5.6	14.4	40	2199	84	5.5	14.6	41	2244	86	5.5
	55	14.0	37	2102	78	5.3	14.2	38	2145	79	5.3	14.4	39	2189	81	5.2
	50	13.8	36	2060	73	5.2	14.0	37	2099	75	5.1	14.2	37	2142	76	5.1
	45	13.8	35	2024	68	5.1	13.9	36	2063	70	5.0	14.2	37	2107	71	5.0
	40	13.9	35	2006	64	5.1	14.0	36	2046	65	5.0	14.2	37	2089	66	4.9
16000 (2° F) (-17° C)	65	14.4	42	2230	87	5.9	14.7	42	2278	89	5.9	14.9	43	2324	91	5.9
	60	14.1	39	2172	83	5.6	14.4	40	2221	85	5.6	14.6	41	2267	87	5.5
	55	13.9	38	2121	78	5.4	14.1	38	2167	80	5.3	14.3	39	2212	82	5.3
	50	13.8	36	2079	74	5.2	14.0	37	2122	76	5.1	14.2	38	2166	77	5.1
	45	13.7	36	2046	69	5.1	13.9	36	2085	71	5.0	14.1	37	2130	72	5.0
	40	13.8	35	2024	64	5.1	14.0	36	2067	66	5.0	14.2	37	2113	67	5.0
16500 (0° F) (-18° C)	60	14.1	40	2198	84	5.6	14.3	41	2244	86	5.6	14.6	42	2292	87	5.6
	55	13.8	38	2140	79	5.4	14.1	39	2189	81	5.3	14.3	40	2234	83	5.3
	50	13.6	36	2095	75	5.2	13.9	37	2144	76	5.2	14.1	38	2188	78	5.1
	45	13.6	36	2063	70	5.1	13.8	37	2108	71	5.1	14.0	37	2152	73	5.0
	40	13.7	36	2040	65	5.1	13.9	37	2092	66	5.1	14.1	37	2134	68	5.0

Table A1

TABULATED CRUISE DATA BY INDICATED AIRSPEED (Page 30 of 30)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	KIAS	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH	MAP	%BHP	RPM	KTAS	GPH
15000 (5° F) (-15° C)	70	15.7	46	2388	95	6.2										
	65	15.3	43	2323	91	5.8	15.6	44	2369	93	5.8	15.8	45	2411	94	5.8
	60	14.9	41	2266	87	5.4	15.2	42	2309	88	5.4	15.4	43	2354	90	5.5
	55	14.7	39	2210	82	5.2	14.9	40	2252	83	5.2	15.1	41	2294	85	5.1
	50	14.5	38	2163	77	5.0	14.7	38	2206	78	5.0	14.9	39	2246	80	4.9
	45	14.4	37	2126	72	4.9	14.6	38	2169	73	4.9	14.9	38	2209	75	4.8
	40	14.5	37	2109	67	4.9	14.7	38	2151	68	4.8	14.9	38	2190	69	4.8
15500 (4° F) (-16° C)	70															
	65	15.3	44	2348	92	5.9	15.5	45	2391	94	5.9					
	60	14.9	41	2289	87	5.5	15.2	42	2335	89	5.5	15.4	43	2378	91	5.6
	55	14.6	40	2233	83	5.2	14.8	40	2275	84	5.2	15.1	41	2320	86	5.2
	50	14.4	38	2187	78	5.0	14.6	39	2228	79	5.0	14.9	40	2269	81	5.0
	45	14.4	37	2150	73	4.9	14.6	38	2191	74	4.9	14.8	39	2232	75	4.9
	40	14.5	37	2132	68	4.9	14.7	38	2173	69	4.9	14.9	39	2213	70	4.8
16000 (2° F) (-17° C)	65															
	60	14.9	42	2314	88	5.6	15.1	43	2358	90	5.6					
	55	14.6	40	2256	83	5.3	14.8	41	2301	85	5.3	15.0	42	2344	87	5.3
	50	14.4	39	2209	79	5.1	14.6	39	2251	80	5.1	14.8	40	2295	82	5.1
	45	14.3	38	2172	73	5.0	14.5	38	2214	75	4.9	14.8	39	2258	76	4.9
	40	14.4	38	2154	68	4.9	14.6	39	2196	70	4.9	14.9	39	2238	71	4.9
16500 (0° F) (-18° C)	60	14.8	42	2336	89	5.6										
	55	14.5	41	2281	84	5.3	14.7	41	2323	86	5.3					
	50	14.3	39	2232	79	5.1	14.6	40	2276	81	5.1	14.8	40	2315	82	5.1
	45	14.3	38	2195	74	5.0	14.5	39	2239	76	5.0	14.7	40	2280	77	5.0
	40	14.4	38	2177	69	5.0	14.5	39	2217	70	4.9					

Table A2

TABULATED CRUISE DATA BY RPM (Page 1 of 24)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D — Mixture: Leaned — Weight: 1760 lbs — Data Basis: *RPM* Model

Propeller: McCauley TM7458/1C172 — Carb Heat: OFF — Flaps: UP

Altitude	RPM	0° F (-18° C) MAP	0° F (-18° C) %BHP	0° F (-18° C) KIAS	0° F (-18° C) KTAS	0° F (-18° C) GPH	20° F (-7° C) MAP	20° F (-7° C) %BHP	20° F (-7° C) KIAS	20° F (-7° C) KTAS	20° F (-7° C) GPH	40° F (4° C) MAP	40° F (4° C) %BHP	40° F (4° C) KIAS	40° F (4° C) KTAS	40° F (4° C) GPH
0 (59° F) (15° C)	2700															
	2600	28.6	102	124	115	14.2	28.4	99	121	115	13.5	27.8	94	118	114	12.6
	2500	27.4	93	118	109	13.1	26.9	89	116	109	12.3	26.5	86	113	109	11.6
	2400	25.2	80	113	104	11.3	24.9	78	111	105	10.7	24.8	75	109	104	10.2
	2300	24.2	73	108	100	10.2	23.6	69	106	100	9.5	23.5	67	104	100	9.1
	2200	22.5	63	103	95	8.9	22.5	62	102	95	8.6	22.5	60	99	94	8.2
	2100	21.4	55	100	91	8.2	21.6	55	96	90	7.9	21.4	53	93	89	7.4
	2000	20.7	50	92	85	7.5	20.7	49	90	85	7.2	20.6	48	88	85	6.9
	1900	20.0	45	87	80	7.0	19.6	42	84	80	6.4	19.5	40	81	79	6.1
	1800	19.0	37	80	75	6.2	19.0	36	76	74	5.9	18.9	35	74	73	5.6
	1700	18.6	33	71	68	5.7	18.4	32	69	68	5.4	18.5	31	64	66	5.2
	1600	18.4	29	59	61	5.3	18.4	29	54	59	5.1	18.5	28	48	55	4.9
	1500	18.5	27	41	48	5.1	18.2	25	43	51	4.7					
500 (57° F) (14° C)	2700															
	2600	28.8	104	123	115	14.4	28.0	98	120	114	13.3	27.5	93	117	114	12.4
	2500	26.5	90	117	109	12.7	26.1	86	115	109	11.9	25.8	83	112	109	11.2
	2400	24.9	80	112	105	11.3	24.6	76	110	104	10.6	24.4	74	108	104	10.1
	2300	24.0	73	107	99	10.1	23.4	69	105	100	9.5	23.0	66	104	100	8.9
	2200	22.5	64	103	95	9.0	22.0	60	101	96	8.4	22.1	59	98	94	8.0
	2100	21.1	55	99	91	8.0	21.2	54	94	89	7.7	21.1	53	92	89	7.4
	2000	20.4	49	91	84	7.4	20.4	49	90	85	7.2	20.2	47	86	84	6.7
	1900	19.8	44	86	80	6.9	19.3	41	83	80	6.4	19.4	41	79	78	6.1
	1800	18.8	37	78	74	6.1	19.0	37	74	72	5.9	18.7	35	72	73	5.6
	1700	18.4	33	69	67	5.7	18.4	32	64	66	5.4	18.4	31	60	64	5.2
	1600	18.0	28	59	61	5.2	18.8	31	41	49	5.2	18.3	28	46	54	4.8
	1500						17.9	25	43	51	4.7					

Table A2

TABULATED CRUISE DATA BY RPM (Page 2 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
0 (59° F) (15° C)	2700	29.3	101	120	118	13.1	29.3	100	118	118	12.7	29.0	96	116	118	12.1
	2600	28.1	94	116	114	12.3	27.3	89	114	114	11.4	27.1	86	112	114	10.9
	2500	25.9	81	111	109	10.8	25.7	79	109	109	10.4	25.6	77	107	109	9.9
	2400	24.6	73	107	104	9.8	24.4	71	105	104	9.3	24.3	69	102	103	8.9
	2300	23.3	65	102	99	8.6	23.2	64	100	99	8.2	23.0	62	97	98	7.8
	2200	21.9	57	98	95	7.7	22.1	57	94	94	7.4	22.0	55	92	93	7.1
	2100	21.3	52	91	89	7.1	21.1	50	88	88	6.8	20.7	48	87	89	6.4
	2000	20.1	45	86	84	6.4	20.1	44	83	83	6.1	20.2	44	80	83	6
	1900	19.7	40	77	77	5.9	19.4	38	76	78	5.6	19.3	37	73	77	5.4
	1800	18.9	35	70	72	5.4	18.9	34	66	71	5.2	18.9	34	63	69	5.0
	1700	18.4	30	60	65	5.0	18.5	30	56	63	4.8	19.2	32	41	53	4.8
	1600	18.5	28	43	53	4.7	18.5	28	41	52	4.6					
	1500															
500 (57° F) (14° C)	2700						28.7	97	116	118	12.4	28.4	94	115	118	11.8
	2600	27.1	89	115	114	11.8	26.7	86	112	113	11.1	26.7	84	110	114	10.7
	2500	25.5	80	110	109	10.7	25.2	77	108	109	10.1	25.3	76	106	108	9.8
	2400	24.2	72	106	104	9.6	24.1	70	103	104	9.2	23.9	68	101	103	8.8
	2300	23.0	64	101	99	8.5	22.9	63	98	98	8.1	22.7	61	96	98	7.7
	2200	21.9	57	95	94	7.7	21.9	56	93	94	7.4	21.7	55	91	94	7.0
	2100	21.0	52	90	89	7.1	20.9	50	88	89	6.7	20.4	47	86	89	6.3
	2000	19.8	44	85	84	6.3	20.0	44	82	83	6.2	19.9	43	79	83	5.9
	1900	19.2	39	78	78	5.8	19.0	38	75	78	5.5	19.1	37	72	76	5.3
	1800	18.7	34	69	71	5.3	18.6	34	65	71	5.1	18.7	33	61	69	4.9
	1700	18.3	30	58	64	4.9	18.3	30	54	62	4.7	18.5	30	47	58	4.6
	1600	18.3	28	43	53	4.7	18.1	26	43	54	4.4					
	1500															

Table A2

TABULATED CRUISE DATA BY RPM (Page 3 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
1000 (55° F) (13° C)	2700															
	2600	28.2	102	122	115	14.1	27.3	95	120	115	13.0	27.4	93	116	114	12.4
	2500	26.4	90	116	109	12.7	25.8	85	114	109	11.8	25.7	83	111	109	11.3
	2400	24.5	78	111	105	11.1	24.2	75	109	105	10.4	24.1	73	107	105	10.0
	2300	23.2	70	107	100	9.8	23.1	68	104	100	9.3	22.9	65	102	99	8.8
	2200	22.3	63	102	95	9.0	21.7	59	100	95	8.3	21.8	58	96	94	7.9
	2100	20.7	54	98	91	7.9	20.9	53	93	89	7.6	20.9	52	91	89	7.3
	2000	20.1	48	90	84	7.3	20.0	47	87	84	6.9	20.0	46	85	84	6.7
	1900	19.2	42	85	80	6.6	19.3	41	81	78	6.3	19.0	39	79	79	6.0
	1800	18.5	36	77	74	6.0	18.5	36	74	73	5.8	18.4	34	71	72	5.5
	1700	18.1	32	69	68	5.6	18.1	31	64	66	5.3	18.0	30	61	65	5.1
	1600	18.0	29	54	58	5.2	18.0	28	50	57	5.0	17.9	27	43	53	4.7
	1500	17.9	26	41	49	4.9										
1500 (54° F) (12° C)	2700															
	2600	27.7	99	120	115	13.8	27.0	94	117	114	12.8	26.5	89	115	114	12.0
	2500	26.0	88	115	109	12.5	25.6	85	112	109	11.7	25.4	82	110	109	11.1
	2400	24.1	77	110	105	10.9	23.9	74	108	104	10.3	23.8	72	106	104	9.8
	2300	23.2	71	106	100	9.9	23.1	69	104	100	9.4	22.6	65	101	99	8.7
	2200	22.0	62	101	95	8.8	21.4	58	99	95	8.1	21.5	58	96	94	7.9
	2100	20.7	54	95	89	7.9	20.7	53	93	89	7.5	20.6	52	90	89	7.2
	2000	19.9	48	89	84	7.2	19.8	47	86	84	6.9	19.7	46	85	84	6.6
	1900	18.9	41	84	80	6.5	19.0	41	79	78	6.3	18.7	39	78	78	5.9
	1800	18.5	37	74	72	6.1	18.3	35	73	73	5.7	18.2	34	70	72	5.4
	1700	17.8	32	68	68	5.5	17.8	31	63	66	5.3	17.8	30	58	64	5.0
	1600	17.6	28	55	59	5.1	18.2	30	41	50	5.1	17.9	28	43	53	4.8

Table A2

TABULATED CRUISE DATA BY RPM (Page 4 of 24)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D   Mixture: Leaned   Weight: 1760 lbs   Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172   Carb Heat: OFF   Flaps: UP

Altitude	RPM	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
1000 (55° F) (13° C)	2700						28.2	95	115	117	12.1	28.0	93	114	118	11.7
	2600	26.8	89	114	114	11.7	26.5	85	111	114	11.0	26.1	82	109	113	10.5
	2500	25.2	79	109	109	10.5	25.1	77	107	109	10.1	25.0	75	105	108	9.7
	2400	23.9	71	105	104	9.5	23.8	69	102	103	9.1	23.6	67	100	103	8.6
	2300	22.7	64	100	99	8.4	22.6	62	97	98	8.0	22.4	60	95	98	7.7
	2200	21.7	57	95	94	7.6	21.6	56	93	94	7.3	21.4	54	90	93	7.0
	2100	20.8	51	89	89	7.0	20.6	50	87	88	6.7	20.2	47	84	88	6.2
	2000	19.6	44	83	84	6.2	19.8	44	81	83	6.1	19.7	43	78	82	5.8
	1900	18.8	38	77	78	5.7	18.8	37	74	77	5.4	18.8	37	70	76	5.2
	1800	18.5	34	67	71	5.3	18.5	33	63	69	5.1	18.2	32	61	70	4.8
	1700	18.0	30	56	64	4.9	18.9	33	41	53	4.9	18.2	30	46	58	4.5
	1600															
	1500															
1500 (54° F) (12° C)	2700											27.6	91	112	117	11.5
	2600	26.7	89	113	114	11.6	26.2	85	110	114	10.9	26.0	82	108	113	10.4
	2500	25.0	79	108	109	10.5	24.8	76	106	108	10.0	24.6	74	104	108	9.5
	2400	23.6	70	103	104	9.4	23.4	68	101	103	8.9	23.3	67	100	103	8.6
	2300	22.4	62	99	99	8.2	22.3	61	96	98	7.9	22.2	60	95	98	7.6
	2200	21.4	56	93	93	7.5	21.3	55	91	94	7.2	20.7	51	90	94	6.7
	2100	20.5	50	88	89	6.9	19.9	47	86	89	6.4	19.9	46	83	88	6.1
	2000	19.4	43	82	83	6.1	19.3	42	79	83	5.9	19.3	41	76	82	5.7
	1900	18.6	38	75	78	5.6	18.6	37	72	76	5.4	18.6	36	68	75	5.2
	1800	18.3	34	65	70	5.2	18.2	33	61	69	5.0	18.3	33	57	67	4.9
	1700	18.0	30	52	61	4.9	18.0	30	47	58	4.7	18.0	29	43	56	4.5
	1600	17.9	28	41	52	4.6										

Table A2

TABULATED CRUISE DATA BY RPM (Page 5 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
2000	2700															
(52° F)	2600	27.2	97	119	114	13.5	26.5	92	117	115	12.6	26.3	88	114	114	11.9
(11° C)	2500	25.2	85	115	110	12.1	25.1	83	112	109	11.5	24.6	79	110	110	10.8
	2400	23.7	75	109	104	10.6	23.6	73	107	104	10.2	23.5	71	105	104	9.7
	2300	22.4	67	105	101	9.5	22.4	66	102	99	9.0	22.2	64	100	99	8.6
	2200	21.3	60	101	95	8.5	21.3	58	97	94	8.1	21.2	57	95	94	7.8
	2100	20.5	53	94	89	7.8	20.4	52	91	89	7.4	20.3	51	89	89	7.1
	2000	19.7	48	88	85	7.2	19.5	46	86	84	6.8	19.1	43	84	84	6.3
	1900	18.6	41	82	80	6.4	18.6	40	79	78	6.1	18.4	38	77	78	5.8
	1800	18.0	36	75	73	5.9	17.9	34	72	73	5.6	17.9	34	68	71	5.3
	1700	17.6	32	65	66	5.5	17.7	31	59	64	5.2	17.7	30	56	63	5.0
	1600	18.0	30	41	50	5.2	17.8	29	43	53	4.9	17.5	27	43	54	4.7
2500	2700															
(50° F)	2600	26.7	95	117	114	13.2	26.6	93	116	114	12.7	25.7	87	114	115	11.7
(10° C)	2500	25	84	113	109	12.0	24.7	81	111	109	11.3	24.5	79	108	109	10.7
	2400	23.4	75	108	104	10.6	23.3	73	106	104	10.1	23.2	71	104	104	9.6
	2300	22.3	67	104	100	9.4	22.1	65	101	99	8.9	21.9	63	99	99	8.4
	2200	20.9	59	100	95	8.4	21.0	58	96	94	8.0	20.9	56	93	94	7.6
	2100	20.2	53	92	89	7.7	20.1	52	91	89	7.3	19.6	48	89	89	6.8
	2000	19.4	47	87	84	7.1	19.3	46	85	84	6.8	18.9	43	82	84	6.2
	1900	18.4	40	81	79	6.4	18.5	40	78	78	6.2	18.2	38	75	78	5.8
	1800	17.8	35	73	73	5.8	17.8	34	70	72	5.5	17.8	34	65	70	5.3
	1700	17.5	31	62	66	5.4	17.4	31	59	65	5.1	17.5	30	53	62	4.9
	1600	17.6	29	41	50	5.1	17.4	28	43	53	4.8	17.4	28	41	52	4.7

Table A2

TABULATED CRUISE DATA BY RPM (Page 6 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
2000 (52° F) (11° C)	2700											27.1	89	111	117	11.2
	2600	26.5	89	112	114	11.6	26.0	84	109	113	10.9	25.7	81	107	113	10.3
	2500	24.3	76	108	110	10.2	24.1	73	106	109	9.7	23.9	71	104	109	9.2
	2400	23.3	69	103	104	9.2	23.2	68	101	103	8.9	23.0	66	98	103	8.5
	2300	22.1	62	97	98	8.1	22.0	60	95	98	7.8	21.9	59	94	98	7.6
	2200	21.1	55	92	93	7.4	21.0	54	90	93	7.1	20.5	51	88	93	6.6
	2100	19.7	47	88	89	6.6	19.7	46	84	88	6.3	19.6	45	82	87	6.0
	2000	19.3	44	81	83	6.2	19.1	42	77	82	5.8	18.8	40	76	82	5.5
	1900	18.3	37	74	78	5.5	18.4	37	70	76	5.3	18.5	36	66	74	5.1
	1800	18.0	34	63	69	5.2	17.9	33	60	69	4.9	17.9	32	57	67	4.7
	1700	17.8	30	50	60	4.8	17.8	29	43	56	4.6	18.0	30	40	54	4.5
	1600															
2500 (50° F) (10° C)	2700											26.6	87	109	117	11.0
	2600	25.6	84	110	113	11.1	25.2	81	109	114	10.5	24.9	78	107	114	10.0
	2500	24.2	76	106	109	10.2	24.0	74	104	108	9.7	23.5	70	103	109	9.1
	2400	23.0	69	102	103	9.2	22.9	67	100	103	8.8	22.8	65	98	103	8.4
	2300	21.8	61	96	98	8.0	21.7	60	94	98	7.7	21.6	58	93	98	7.5
	2200	20.8	55	91	94	7.3	20.2	51	90	94	6.8	20.2	50	87	93	6.5
	2100	19.6	47	86	88	6.5	19.5	46	83	88	6.2	19.4	45	81	87	6.0
	2000	19.0	43	79	83	6.1	18.8	41	76	82	5.7	18.8	40	73	81	5.5
	1900	18.1	37	73	77	5.5	18.2	36	68	75	5.3	18.3	36	64	73	5.1
	1800	17.8	33	61	69	5.1	17.8	33	57	67	4.9	17.8	32	53	65	4.7
	1700	17.6	30	47	58	4.8	17.6	29	43	56	4.6	17.6	29	41	55	4.4
	1600															

Table A2

TABULATED CRUISE DATA BY RPM (Page 7 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
3000 (48° F) (9° C)	2600	26.1	92	116	113	12.9	26.1	91	114	114	12.4	25.4	86	112	114	11.5
	2500	24.4	82	112	109	11.6	24.3	80	110	109	11.1	24.1	77	107	109	10.6
	2400	23.1	74	107	104	10.5	23.0	72	105	104	10.0	22.9	70	103	104	9.5
	2300	22.0	66	103	99	9.3	21.8	64	100	99	8.8	21.6	62	98	98	8.3
	2200	20.9	59	97	94	8.3	20.7	57	95	94	7.9	20.6	55	92	93	7.5
	2100	20.0	53	92	89	7.6	19.8	51	90	89	7.3	19.3	47	88	89	6.7
	2000	18.7	45	87	85	6.8	18.7	44	83	84	6.5	18.8	43	80	82	6.3
	1900	18.2	40	79	79	6.3	18.0	38	77	78	5.9	17.9	37	74	78	5.6
	1800	17.6	35	72	72	5.8	17.6	34	68	71	5.5	17.6	34	63	69	5.3
	1700	17.3	31	60	64	5.3	17.1	30	57	64	5.1	17.2	29	53	62	4.8
	1600	17.3	28	41	50	5.0	17.1	27	43	54	4.8					
3500 (47° F) (8° C)	2600	25.6	90	114	113	12.7	25.6	89	112	113	12.1	25.6	87	111	114	11.7
	2500	24.2	82	111	110	11.6	23.8	78	108	109	10.9	23.5	75	106	109	10.2
	2400	22.7	72	106	104	10.2	22.6	70	104	104	9.8	22.7	69	102	104	9.5
	2300	21.7	65	102	99	9.1	21.4	63	99	99	8.6	21.3	61	96	98	8.2
	2200	20.6	58	96	94	8.2	20.4	56	93	93	7.8	20.3	55	92	94	7.5
	2100	19.7	52	91	89	7.5	19.6	51	89	89	7.2	19.2	47	86	88	6.7
	2000	18.4	44	86	85	6.7	18.4	43	82	83	6.4	18.3	42	79	83	6.1
	1900	17.9	39	78	78	6.2	17.9	38	75	77	5.9	17.8	37	72	77	5.6
	1800	17.4	35	70	72	5.7	17.4	34	65	70	5.4	17.4	33	61	69	5.2
	1700	17.1	31	57	63	5.3	17.0	30	55	63	5.0	17.0	29	50	60	4.8
	1600	17.0	28	41	51	4.9	17.0	28	41	52	4.8					

Table A2

TABULATED CRUISE DATA BY RPM (Page 8 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
3000 (48° F) (9° C)	2600	25.3	84	109	113	11.0	24.9	80	107	113	10.4	24.6	77	105	113	9.8
	2500	23.9	75	105	108	10.0	23.7	73	103	108	9.5	23.5	70	101	108	9.1
	2400	22.7	68	101	103	9.1	22.6	66	99	104	8.7	22.5	65	97	103	8.4
	2300	21.5	60	95	98	8.0	21.4	59	94	98	7.7	20.8	55	92	99	7.1
	2200	20.5	54	90	93	7.2	19.9	50	89	94	6.7	19.9	49	86	93	6.4
	2100	19.3	46	85	88	6.4	19.2	45	82	87	6.1	19.1	44	79	86	5.9
	2000	18.6	41	78	82	5.9	18.6	41	75	81	5.7	18.4	39	73	81	5.4
	1900	18.0	37	70	76	5.4	18.0	36	67	75	5.2	18.0	36	62	73	5.0
	1800	17.4	32	61	70	5.0	17.4	32	57	68	4.8	18.3	34	41	56	4.9
	1700	17.8	31	41	54	4.8	17.3	29	43	57	4.5					
	1600															
3500 (47° F) (8° C)	2600	24.7	81	109	114	10.7	24.8	80	106	113	10.3	24.3	76	105	113	9.8
	2500	23.5	74	104	108	9.9	23.3	72	102	108	9.4	23.2	69	100	107	9.0
	2400	22.5	67	100	104	9.0	22.4	66	98	103	8.6	21.7	61	96	103	7.9
	2300	21.3	60	95	99	7.9	21.2	58	93	98	7.6	20.6	55	90	98	7.0
	2200	19.8	51	90	94	6.9	19.7	50	87	93	6.6	19.6	49	85	92	6.3
	2100	19.0	46	83	88	6.3	18.9	44	81	87	6.0	18.8	43	78	86	5.8
	2000	18.2	41	76	82	5.8	18.3	40	74	81	5.6	18.3	39	70	79	5.4
	1900	17.8	36	69	75	5.4	17.8	36	64	73	5.2	17.8	35	60	72	5.0
	1800	17.3	32	58	68	5.0	17.4	32	53	65	4.8	17.3	31	50	64	4.6
	1700	17.3	30	41	54	4.7	17.0	29	43	57	4.4					
	1600															

Table A2

TABULATED CRUISE DATA BY RPM (Page 9 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis: *RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP	

Altitude	RPM	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
4000 (45° F) (7° C)	2600						25.1	87	111	113	11.9	25.1	85	110	114	11.4
	2500	23.9	81	110	109	11.5	23.7	78	107	109	10.9	23.2	74	105	108	10.2
	2400	22.5	72	105	104	10.2	22.6	71	103	104	9.8	22.3	68	101	104	9.3
	2300	21.4	64	100	99	9.0	21.2	62	98	99	8.6	21.1	60	96	98	8.2
	2200	20.4	57	95	94	8.2	20.2	56	93	93	7.7	20.1	54	91	93	7.4
	2100	19.4	51	90	89	7.5	18.9	48	88	89	6.9	18.9	47	85	88	6.6
	2000	18.3	44	84	84	6.6	18.2	42	81	83	6.3	18.1	41	78	82	6.0
	1900	17.6	39	77	78	6.1	17.7	38	73	77	5.8	17.4	36	71	77	5.5
	1800	17.2	34	68	71	5.6	17.2	34	63	69	5.4	17.0	32	62	70	5.1
	1700	16.7	30	58	64	5.2	16.9	31	53	62	5.1	16.9	29	43	56	4.7
	1600	16.8	28	41	51	4.9										
4500 (43° F) (6° C)	2600						24.6	85	110	113	11.6	24.6	83	108	113	11.2
	2500	23.9	81	109	109	11.5	23.4	77	106	108	10.7	23.1	74	104	108	10.1
	2400	22.4	72	104	104	10.2	22.2	69	102	104	9.7	21.9	67	100	103	9.1
	2300	21.1	63	99	99	8.9	20.9	61	97	98	8.5	20.8	60	95	99	8.1
	2200	20.1	57	95	94	8.1	19.9	55	92	94	7.6	19.4	51	90	94	7.1
	2100	18.8	49	89	89	7.2	18.7	47	86	88	6.8	18.6	46	83	88	6.5
	2000	18.0	43	83	84	6.5	18.0	42	79	83	6.2	17.9	41	76	82	5.9
	1900	17.5	38	75	77	6.0	17.4	37	72	77	5.7	17.3	36	69	76	5.4
	1800	17.0	34	66	71	5.6	17.0	33	61	69	5.3	16.9	32	59	68	5.0
	1700	16.5	30	56	63	5.1	16.6	30	50	60	4.9	16.6	29	43	56	4.7
	1600	16.5	27	41	52	4.8										

Table A2

TABULATED CRUISE DATA BY RPM (Page 10 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
4000	2600	24.5	80	108	113	10.6	24.1	77	105	113	10.0	24.3	77	103	112	9.8
(45° F)	2500	23.1	72	103	108	9.7	23.1	71	101	108	9.3	22.9	69	99	107	8.9
(7° C)	2400	22.2	67	99	104	8.9	21.5	62	97	103	8.2	21.3	60	94	103	7.8
	2300	21.0	59	94	98	7.9	20.3	55	92	98	7.2	20.3	54	89	98	6.9
	2200	19.6	51	88	93	6.9	19.4	49	86	93	6.5	19.3	48	83	92	6.2
	2100	18.7	45	82	87	6.2	18.7	44	79	86	6.0	18.6	43	76	86	5.7
	2000	18.0	40	75	81	5.7	18.1	40	72	80	5.5	18.0	39	69	80	5.3
	1900	17.5	36	67	75	5.3	17.6	36	62	73	5.1	17.6	35	58	71	4.9
	1800	17.3	33	54	65	4.9	17.1	32	52	65	4.7	17.2	31	47	62	4.5
	1700															
	1600															
4500	2600	24.0	79	107	114	10.4	23.9	77	104	113	10.0	23.5	73	102	112	9.4
(43° F)	2500	22.8	71	102	108	9.6	22.7	70	100	108	9.2	22.6	68	98	108	8.8
(6° C)	2400	21.4	63	98	104	8.5	21.2	61	96	103	8.1	21.3	61	93	102	7.9
	2300	20.7	58	93	98	7.8	20.2	55	90	98	7.2	20.0	53	88	97	6.8
	2200	19.3	50	87	93	6.7	19.2	49	85	92	6.4	19.1	47	82	92	6.1
	2100	18.5	45	81	87	6.2	18.4	43	78	86	5.9	18.3	42	75	85	5.6
	2000	17.8	40	74	81	5.6	17.8	39	71	80	5.4	17.8	38	68	79	5.2
	1900	17.4	36	64	73	5.3	17.4	35	60	72	5.0	17.2	34	58	72	4.8
	1800	17.0	32	53	65	4.8	17.1	32	48	62	4.7	17.0	31	43	59	4.5
	1700															
	1600															

Table A2

TABULATED CRUISE DATA BY RPM (Page 11 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
5000 (41° F) (5° C)	2600											24.1	81	107	112	10.9
	2500	22.9	76	107	108	10.9	22.7	74	106	109	10.4	22.5	72	104	109	9.9
	2400	21.7	69	104	105	9.8	21.7	67	101	103	9.4	21.2	64	99	104	8.8
	2300	20.8	63	99	99	8.8	20.7	61	96	99	8.4	20.6	59	94	98	8.0
	2200	19.8	56	93	93	7.9	19.7	55	91	94	7.6	19.1	50	89	94	6.9
	2100	18.6	48	88	89	7.1	18.4	47	85	88	6.7	18.3	45	82	87	6.4
	2000	17.8	43	81	83	6.5	17.7	41	78	82	6.1	17.6	40	75	81	5.8
	1900	17.3	38	74	77	6.0	17.1	37	71	76	5.6	17.1	36	67	75	5.4
	1800	16.8	34	64	70	5.5	16.8	33	60	68	5.2	16.6	32	57	68	4.9
	1700	16.4	30	53	62	5.1	16.5	30	47	58	4.9	16.5	29	43	57	4.7
5500 (39° F) (4° C)	2600											23.7	79	106	112	10.7
	2500	22.8	77	107	109	10.9	22.4	73	104	108	10.3	22.4	72	102	108	9.8
	2400	21.6	69	102	104	9.8	21.4	66	100	103	9.3	20.9	63	98	104	8.7
	2300	20.6	62	97	99	8.8	20.5	61	95	99	8.4	19.9	56	93	98	7.7
	2200	19.6	56	92	94	7.9	18.9	51	90	94	7.2	18.9	50	87	93	6.9
	2100	18.3	47	87	89	7.0	18.2	46	84	88	6.6	18.1	45	81	87	6.3
	2000	17.5	42	80	83	6.4	17.5	41	77	82	6.1	17.4	40	74	81	5.8
	1900	17.0	38	72	76	5.9	17.0	37	69	75	5.6	16.8	35	66	75	5.3
	1800	16.6	34	62	69	5.4	16.4	32	59	68	5.1	16.5	32	54	66	4.9
	1700	16.3	30	49	60	5.1	16.3	29	43	56	4.8					

Table A2

TABULATED CRUISE DATA BY RPM (Page 12 of 24)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D | Mixture: Leaned | Weight: 1760 lbs | Data Basis: *RPM* Model

Propeller: McCauley TM7458/1C172 | Carb Heat: OFF | Flaps: UP

Altitude	RPM	60° F (16° C) MAP	%BHP	KIAS	KTAS	GPH	80° F (27° C) MAP	%BHP	KIAS	KTAS	GPH	100° F (38° C) MAP	%BHP	KIAS	KTAS	GPH
5000 (41° F) (5° C)	2600	24.1	80	105	113	10.5	23.4	75	104	113	9.8	23.3	73	101	112	9.4
	2500	22.3	69	102	109	9.4	22.6	70	100	108	9.2	22.2	67	97	107	8.6
	2400	21.3	63	96	102	8.5	20.8	60	94	103	7.9	21.1	60	92	102	7.8
	2300	20.0	55	92	98	7.4	19.8	54	89	98	7.0	20.1	54	87	97	6.9
	2200	19.0	49	85	92	6.6	18.9	48	83	92	6.3	18.8	47	81	91	6.1
	2100	18.2	44	79	87	6.1	18.2	43	76	85	5.8	18.1	42	74	85	5.6
	2000	17.7	40	72	80	5.6	17.7	39	69	79	5.4	17.4	37	67	79	5.1
	1900	17.2	36	64	74	5.3	17.0	34	60	73	4.9	17.1	34	55	70	4.8
	1800	17.4	34	41	56	5.0	16.8	31	47	62	4.6	16.8	31	43	60	4.5
	1700															
5500 (39° F) (4° C)	2600	23.6	78	104	113	10.3	23.0	73	103	113	9.6	22.8	71	101	113	9.2
	2500	21.9	68	101	108	9.2	21.7	66	98	107	8.7	21.5	64	96	108	8.4
	2400	21.1	63	95	102	8.4	20.5	59	93	102	7.8	20.8	59	91	102	7.7
	2300	19.7	54	90	97	7.2	19.5	53	88	97	6.9	19.4	51	86	97	6.6
	2200	18.7	49	85	92	6.5	18.6	47	83	92	6.2	18.6	46	79	91	6.0
	2100	18.0	43	78	86	6.0	17.9	42	75	85	5.7	17.9	41	72	84	5.5
	2000	17.4	39	71	80	5.5	17.5	39	68	79	5.4	17.2	37	65	79	5.0
	1900	16.8	34	62	74	5.1	17.0	34	56	71	4.9	17.0	34	52	68	4.7
	1800	17.1	34	41	56	4.9	16.8	32	43	59	4.6	16.5	30	43	60	4.4
	1700															

Table A2

TABULATED CRUISE DATA BY RPM (Page 13 of 24)

USAFA CCFT Cessna 150/150 HP

Engine: Lycoming O-320-E2D Mixture: Leaned Weight: 1760 lbs Data Basis: *RPM* Model
Propeller: McCauley TM7458/1C172 Carb Heat: OFF Flaps: UP

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
6000 (38° F) (3° C)	2600											23.2	77	105	112	10.5
	2500	22.2	74	107	109	10.7	22.3	73	103	108	10.2	21.8	70	102	108	9.6
	2400	21.3	68	101	103	9.7	21.1	65	99	103	9.1	20.9	64	96	103	8.7
	2300	20.4	62	97	99	8.7	19.7	57	94	99	8.0	19.5	55	91	98	7.5
	2200	18.8	52	92	94	7.5	18.8	51	89	93	7.2	18.6	49	86	93	6.8
	2100	18.0	47	85	88	6.9	17.9	45	82	88	6.5	17.8	44	79	87	6.2
	2000	17.3	41	79	83	6.3	17.2	40	75	81	6.0	17.2	39	72	80	5.7
	1900	16.8	37	71	76	5.8	16.7	36	68	75	5.5	16.8	36	64	74	5.4
	1800	16.4	33	59	68	5.4	16.2	32	57	68	5.1	17.0	34	41	56	5.1
	1700	16.5	31	41	53	5.1	16.1	29	43	57	4.8					
6500 (36° F) (2° C)	2600															
	2500	22.0	74	105	109	10.6	22.1	73	102	108	10.2	21.7	69	100	107	9.5
	2400	21.0	67	100	103	9.5	20.8	65	98	103	9.1	20.7	63	95	102	8.6
	2300	19.6	58	96	99	8.3	19.4	56	93	98	7.8	19.2	54	90	98	7.4
	2200	18.6	52	90	93	7.4	18.5	50	87	93	7.0	18.3	49	85	92	6.7
	2100	17.8	46	84	88	6.8	17.6	45	81	87	6.4	17.6	43	78	86	6.1
	2000	17.0	41	77	82	6.2	17.0	40	74	81	5.9	17.0	39	71	80	5.6
	1900	16.6	37	69	75	5.7	16.4	35	67	75	5.4	16.4	34	62	74	5.2
	1800	16.0	32	60	69	5.2	16.1	32	54	66	5.0	16.7	34	41	56	5.0
	1700	16.1	30	41	54	5.0	15.8	29	43	57	4.7					

Table A2

TABULATED CRUISE DATA BY RPM (Page 14 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
6000 (38° F) (3° C)	2600	23.2	76	103	112	10.1	23.2	75	102	113	9.7	22.6	71	100	112	9.1
	2500	21.9	68	99	107	9.2	21.4	65	98	108	8.6	21.5	65	94	107	8.4
	2400	20.7	62	94	102	8.3	20.6	60	92	102	7.9	20.5	58	90	102	7.6
	2300	19.4	54	89	97	7.1	19.6	54	87	97	7.0	19.1	51	84	96	6.5
	2200	18.4	48	84	92	6.4	18.3	46	81	92	6.1	18.3	46	78	90	5.9
	2100	17.8	43	76	86	5.9	17.7	42	73	84	5.7	17.7	41	71	83	5.4
	2000	17.1	38	69	79	5.4	17.0	37	67	79	5.2	17.1	37	62	77	5.0
	1900	16.6	34	60	73	5.0	16.7	34	55	70	4.8	16.7	33	52	69	4.6
	1800	16.4	31	47	62	4.7						16.2	29	43	61	4.3
	1700															
6500 (36° F) (2° C)	2600	22.7	74	102	111	9.8	22.7	73	100	112	9.5	22.1	69	99	113	8.9
	2500	21.4	67	98	107	9.0	21.3	65	95	107	8.6	21.2	64	93	106	8.3
	2400	20.5	61	93	103	8.2	20.4	59	91	102	7.8	20.2	58	88	101	7.5
	2300	19.4	55	88	97	7.2	19.0	51	85	97	6.7	18.8	50	83	97	6.4
	2200	18.2	47	83	92	6.3	18.2	46	79	91	6.1	18.1	45	77	90	5.8
	2100	17.6	42	75	85	5.8	17.5	41	72	84	5.6	17.5	41	69	83	5.4
	2000	17.1	39	68	79	5.5	16.8	37	65	79	5.1	17.0	37	59	75	5.0
	1900	16.6	34	56	71	5.0	16.6	34	52	68	4.8	16.6	33	48	66	4.6
	1800	16.4	32	43	59	4.7	16.1	30	43	61	4.4					
	1700															

Table A2

TABULATED CRUISE DATA BY RPM (Page 15 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
7000 (34° F) (1° C)	2600															
	2500	21.6	72	104	109	10.4	21.5	70	102	108	9.9	21.2	67	100	108	9.3
	2400	20.6	65	99	103	9.3	20.6	64	97	103	9.0	20.4	62	94	103	8.5
	2300	19.3	58	95	99	8.1	19.4	57	91	97	7.9	19.0	54	89	98	7.3
	2200	18.4	51	89	93	7.3	18.2	49	86	93	6.9	18.4	50	83	92	6.8
	2100	17.5	45	83	88	6.7	17.4	44	80	87	6.3	17.4	43	76	86	6.0
	2000	16.8	40	76	82	6.1	16.8	39	72	80	5.8	16.8	39	69	79	5.6
	1900	16.4	37	67	75	5.7	16.3	35	64	74	5.4	16.3	35	59	72	5.1
	1800	16.0	33	56	67	5.2	16.0	32	51	64	5.0	16.0	31	47	62	4.8
	1700	15.8	30	41	54	4.9	15.5	28	43	58	4.6					
7500 (32° F) (0° C)	2600															
	2500	21.2	71	103	109	10.2	21.0	68	101	109	9.6	21.0	67	98	107	9.2
	2400	20.5	65	98	103	9.3	20.2	63	95	103	8.8	20.2	62	93	103	8.5
	2300	19.3	58	92	97	8.1	18.8	55	90	98	7.6	19.0	55	88	97	7.4
	2200	18.1	51	88	93	7.2	17.9	49	85	92	6.8	17.8	47	83	92	6.5
	2100	17.3	45	81	87	6.6	17.2	44	78	86	6.2	17.2	43	75	85	6.0
	2000	16.6	40	74	81	6.0	16.6	39	71	80	5.7	16.6	38	67	78	5.5
	1900	16.0	35	67	75	5.5	16.1	35	61	73	5.3	16.0	34	58	72	5.0
	1800	15.7	32	55	67	5.1	16.3	34	41	56	5.1	16.0	32	43	59	4.8
	1700	15.6	30	40	54	4.9	15.2	27	43	58	4.5					

Table A2

TABULATED CRUISE DATA BY RPM (Page 16 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
7000	2600	22.3	72	100	111	9.6	22.2	71	99	112	9.3	22.2	70	97	112	9.0
(34° F)	2500	21.4	67	97	108	9.1	21.0	64	94	106	8.5	21.0	63	92	107	8.2
(1° C)	2400	20.3	60	92	102	8.1	19.6	56	90	102	7.5	19.6	55	87	101	7.2
	2300	19.2	54	86	97	7.2	18.7	51	84	96	6.6	18.7	50	81	95	6.4
	2200	18.0	47	81	91	6.3	17.9	46	78	90	6.0	17.9	44	75	89	5.8
	2100	17.3	42	73	84	5.8	17.3	41	71	84	5.5	17.3	40	67	82	5.3
	2000	16.6	37	67	79	5.3	16.7	37	62	77	5.1	16.7	36	59	76	4.9
	1900	16.3	34	56	71	4.9	17.0	36	41	59	4.9	16.6	34	43	62	4.6
	1800	16.2	32	40	57	4.7	15.8	29	43	61	4.3					
	1700															
7500	2600						21.8	69	97	111	9.1	21.8	68	96	111	8.8
(32° F)	2500	21.1	67	96	107	9.0	20.9	64	94	107	8.5	20.7	62	91	106	8.1
(0° C)	2400	19.6	58	91	102	7.8	19.4	56	89	102	7.4	19.3	54	86	101	7.1
	2300	18.9	53	85	97	7.1	18.5	50	83	96	6.6	18.4	49	80	95	6.3
	2200	17.8	46	79	91	6.2	17.7	45	77	90	5.9	17.7	44	73	88	5.7
	2100	17.1	41	72	84	5.7	17.1	41	69	83	5.5	17.1	40	65	82	5.3
	2000	16.6	38	64	78	5.3	16.5	36	60	76	5.0	16.4	35	58	75	4.8
	1900	16.1	34	53	69	4.9	16.3	34	47	65	4.7	16.2	33	43	63	4.5
	1800	15.7	30	43	61	4.5										
	1700															

Table A2

TABULATED CRUISE DATA BY RPM (Page 17 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
8000 (30° F) (-1° C)	2600															
	2500	21.4	72	102	108	10.3	20.8	68	100	108	9.5	20.9	67	97	107	9.2
	2400	20.0	64	97	103	9.1	19.6	60	95	103	8.5	19.4	58	92	103	8.1
	2300	19.0	57	91	97	8.1	18.9	55	89	97	7.7	18.8	54	87	97	7.3
	2200	17.8	50	86	93	7.1	17.7	48	84	92	6.7	17.5	46	81	92	6.4
	2100	17.0	44	80	87	6.5	17.0	43	77	86	6.2	16.9	42	73	84	5.9
	2000	16.4	39	73	80	5.9	16.4	39	69	79	5.7	16.4	38	65	77	5.4
	1900	15.8	35	65	75	5.5	15.8	34	61	73	5.2	16.0	34	54	69	5.0
	1800	15.6	32	53	65	5.1	15.6	31	47	62	4.9	15.8	32	40	57	4.8
8500 (29° F) (-2° C)	2600															
	2500	21.0	70	101	108	10.1	20.4	66	99	108	9.4	20.3	65	96	107	8.9
	2400	19.7	63	95	102	9.0	19.3	59	94	103	8.4	19.4	59	90	102	8.1
	2300	18.8	57	91	98	8.0	18.6	55	88	97	7.6	18.1	51	86	97	7.0
	2200	17.5	49	85	93	7.0	17.4	47	83	92	6.6	17.4	46	79	91	6.3
	2100	16.8	44	79	86	6.4	16.8	43	75	85	6.1	16.7	42	72	84	5.8
	2000	16.2	39	71	80	5.9	16.2	38	67	78	5.6	16.0	37	65	78	5.3
	1900	15.6	35	63	74	5.4	15.8	35	57	71	5.2	15.7	34	53	69	5.0
	1800	15.8	33	41	56	5.2	15.6	32	43	59	4.9	15.3	30	43	60	4.6
9000 (27° F) (-3° C)	2500	20.5	69	99	107	9.9	20.5	68	98	108	9.5	19.9	63	95	107	8.7
	2400	19.4	62	94	102	8.8	19.3	60	92	102	8.4	19.1	58	89	101	8.0
	2300	18.1	54	90	98	7.6	18.0	52	87	98	7.2	17.9	51	84	96	6.9
	2200	17.3	48	84	92	6.9	17.1	46	82	92	6.5	17.1	46	78	90	6.2
	2100	16.6	43	77	86	6.3	16.5	42	74	85	6	16.5	41	71	83	5.7
	2000	16.1	40	70	80	5.9	15.8	37	67	79	5.5	15.9	37	62	77	5.3
	1900	15.5	35	60	73	5.3	15.6	34	55	70	5.1	15.6	34	51	68	4.9
	1800	15.5	32	41	57	5.1	15.3	31	43	60	4.8					
9500 (25° F) (-4° C)	2500	20.1	67	98	107	9.6	20.1	66	96	107	9.2	19.6	62	94	107	8.6
	2400	19.2	61	93	102	8.7	18.9	59	90	101	8.2	18.9	58	88	101	7.9
	2300	17.9	53	88	97	7.6	17.8	52	86	97	7.2	17.7	50	83	96	6.8
	2200	17.1	48	83	92	6.8	17.0	46	80	91	6.5	16.9	45	76	90	6.2
	2100	16.4	43	76	85	6.2	16.3	42	72	84	5.9	16.3	41	69	83	5.7
	2000	15.9	39	69	79	5.8	15.6	37	65	79	5.4	15.7	36	60	76	5.2
	1900	15.3	34	58	71	5.3	15.3	33	55	70	5.0	15.8	35	41	60	5.0
	1800	15.3	32	41	57	5.0	15.0	30	43	60	4.7					

Table A2

TABULATED CRUISE DATA BY RPM (Page 18 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis: *RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP	

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
8000	2600						21.3	68	96	110	8.9	21.3	67	94	110	8.6
(30° F)	2500	20.5	64	94	107	8.6	20.2	61	93	107	8.1	20.0	59	90	106	7.8
(-1° C)	2400	19.3	57	90	102	7.7	19.1	55	87	101	7.3	19.0	54	85	101	7.0
	2300	18.7	53	84	97	7.0	18.1	49	82	96	6.4	18.2	48	79	95	6.2
	2200	17.5	46	78	90	6.1	17.4	44	75	89	5.9	17.5	44	72	88	5.6
	2100	16.9	41	70	83	5.6	16.9	40	67	82	5.4	16.7	39	64	82	5.1
	2000	16.4	37	61	76	5.2	16.3	36	57	74	5.0	16.2	35	55	74	4.8
	1900	15.9	33	51	68	4.8	16.3	34	41	60	4.7	16.0	32	43	63	4.5
	1800	15.4	29	43	61	4.4										
8500	2600											20.9	65	93	110	8.4
(29° F)	2500	20.3	64	93	106	8.6	20.1	61	90	105	8.1	19.9	59	88	105	7.7
(-2° C)	2400	19.0	56	88	102	7.6	18.9	54	86	101	7.2	18.7	53	84	101	6.9
	2300	18.1	50	83	96	6.7	18.0	49	80	95	6.4	17.9	48	78	94	6.1
	2200	17.3	45	77	90	6.0	17.3	44	73	88	5.8	17.3	43	70	87	5.6
	2100	16.7	41	69	83	5.5	16.7	40	65	82	5.4	16.5	39	62	81	5.1
	2000	16.0	36	60	76	5.1	16.2	36	55	73	4.9	16.2	35	52	72	4.7
	1900	15.9	34	47	65	4.8	15.9	33	43	63	4.6					
	1800															
9000	2500	19.9	62	92	106	8.4	19.5	59	91	107	7.9	19.5	58	88	106	7.6
(27° F)	2400	18.7	55	87	101	7.4	18.5	53	85	101	7.1	18.4	52	83	100	6.7
(-3° C)	2300	17.8	49	81	96	6.6	17.7	48	79	95	6.3	17.7	47	76	94	6.0
	2200	17.1	45	75	89	6.0	17.1	44	71	88	5.7	17.1	43	69	87	5.5
	2100	16.5	40	66	82	5.5	16.3	39	64	82	5.2	16.4	38	60	80	5.0
	2000	15.8	36	59	76	5.0	16.1	36	55	74	5.0	15.9	35	51	72	4.7
	1900	15.6	33	43	62	4.7	15.8	33	40	60	4.6					
	1800															
9500	2500	19.5	61	91	106	8.2	19.6	60	89	106	7.9	19.3	57	86	105	7.5
(25° F)	2400	18.8	56	86	101	7.5	18.3	52	84	101	7.0	18.2	51	81	99	6.7
(-4° C)	2300	17.6	49	80	95	6.5	17.5	48	77	94	6.2	17.5	47	75	93	6.0
	2200	16.9	44	73	88	5.9	16.9	43	70	87	5.7	16.9	43	67	87	5.5
	2100	16.3	40	64	81	5.4	16.3	40	63	81	5.3	16.2	38	58	79	5.0
	2000	15.6	35	57	75	5.0	16.5	38	41	62	5.1	15.8	35	47	69	4.6
	1900	15.5	33	43	63	4.7	15.3	32	43	64	4.4					
	1800															

Table A2

TABULATED CRUISE DATA BY RPM (Page 19 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
10000	2500	19.7	65	96	106	9.4	19.7	64	94	106	9.0	19.7	63	93	107	8.7
(23° F)	2400	18.5	58	93	103	8.4	18.5	57	90	102	8.0	18.3	55	87	101	7.6
(-5° C)	2300	17.7	53	87	97	7.5	17.5	51	84	96	7.1	17.4	49	81	96	6.7
	2200	16.8	47	81	91	6.7	16.7	46	78	90	6.4	16.7	45	75	89	6.1
	2100	16.2	42	74	85	6.2	16.1	41	71	83	5.9	16.1	40	67	82	5.6
	2000	15.6	38	65	78	5.7	15.5	37	62	77	5.4	15.5	36	58	75	5.1
	1900	15.2	34	56	71	5.2	15.2	34	51	68	5.0	15.4	34	43	62	4.9
	1800	14.9	31	41	58	4.9	14.6	29	43	61	4.6					
10500	2500						19.3	62	93	106	8.8	19.3	61	91	106	8.5
(22° F)	2400	18.6	59	91	102	8.5	18.2	56	89	102	7.9	18.3	56	86	101	7.7
(-6° C)	2300	17.4	52	86	97	7.4	17.3	50	83	96	7.0	17.2	49	80	95	6.6
	2200	16.6	46	80	91	6.6	16.5	45	77	90	6.3	16.5	44	73	88	6.0
	2100	16.0	42	73	84	6.1	15.9	41	69	83	5.8	15.9	40	66	82	5.6
	2000	15.2	37	66	79	5.5	15.3	36	60	76	5.3	15.2	35	57	75	5.0
	1900	15.1	34	53	69	5.2	15.2	34	47	65	5.0	15.2	33	43	63	4.8
	1800	14.8	31	40	57	4.9										
11000	2500											18.9	60	89	105	8.2
(20° F)	2400	18.4	59	90	102	8.4	18.2	56	87	101	7.9	18.0	54	84	100	7.5
(-7° C)	2300	17.2	51	85	96	7.2	17.0	50	82	96	6.9	17.0	48	79	95	6.5
	2200	16.4	46	78	90	6.5	16.3	45	75	89	6.2	16.3	44	72	88	5.9
	2100	15.8	41	71	84	6.0	15.7	40	67	82	5.7	15.7	40	64	81	5.5
	2000	15.3	38	63	77	5.6	15.2	36	58	75	5.3	15.3	36	52	72	5.1
	1900	15.3	36	41	59	5.3	15.0	34	43	62	5.0	15.0	33	43	63	4.8
11500	2500											18.5	58	87	104	8.0
(18° F)	2400	18.0	57	88	101	8.2	17.7	55	86	101	7.7	17.5	53	83	100	7.3
(-8° C)	2300	16.9	50	83	96	7.1	16.7	48	81	96	6.7	16.7	48	77	94	6.5
	2200	16.0	45	78	91	6.4	16.1	44	74	89	6.1	16.1	43	70	87	5.9
	2100	15.6	41	69	83	5.9	15.4	39	67	83	5.6	15.4	38	62	81	5.3
	2000	14.9	36	61	76	5.4	15.0	36	56	74	5.2	15.0	35	51	72	5.0
	1900	15.0	35	41	59	5.2	14.7	33	43	63	4.9					

Table A2

TABULATED CRUISE DATA BY RPM (Page 20 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP

Data Basis: *RPM* Model

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
10000	2500	19.2	59	90	106	8.1	19.2	58	87	105	7.7	18.9	56	85	105	7.3
(23° F)	2400	18.2	53	85	101	7.2	18.1	52	82	100	6.9	18.0	51	79	99	6.6
(-5° C)	2300	17.3	48	79	95	6.4	17.3	47	76	94	6.1	17.2	46	73	92	5.9
	2200	16.7	44	71	88	5.8	16.7	43	69	87	5.6	16.7	42	66	86	5.4
	2100	16.0	39	64	82	5.3	16.0	38	60	80	5.1	16.1	38	57	78	5.0
	2000	15.6	36	52	72	5.0	15.7	35	47	68	4.8	15.7	35	43	66	4.6
	1900	15.4	33	43	63	4.7										
	1800															
10500	2500	19.3	60	89	106	8.1	18.8	57	86	105	7.6	18.6	55	84	105	7.2
(22° F)	2400	17.9	53	83	100	7.1	17.8	51	81	99	6.8	17.8	50	78	98	6.5
(-6° C)	2300	17.1	48	77	94	6.3	17.1	46	74	93	6.1	17.0	45	71	92	5.8
	2200	16.5	43	70	87	5.8	16.5	43	68	87	5.6	16.5	42	64	86	5.4
	2100	16.0	40	62	81	5.4	15.8	38	57	78	5.1	15.9	38	54	77	4.9
	2000	16.1	38	41	62	5.1	15.4	35	47	69	4.7	15.6	35	40	64	4.6
	1900	14.9	32	43	64	4.5										
	1800															
11000	2500	18.9	59	87	105	8.0	18.4	56	85	105	7.4	18.4	55	82	104	7.1
(20° F)	2400	17.7	52	82	100	7.0	17.5	50	80	100	6.7	17.6	50	76	98	6.4
(-7° C)	2300	16.9	47	76	94	6.2	16.8	46	73	92	6.0	16.8	45	70	91	5.7
	2200	16.3	43	69	87	5.7	16.3	42	66	86	5.5	16.1	40	62	85	5.2
	2100	15.6	38	60	80	5.2	15.7	38	56	78	5.1	15.8	38	51	75	4.9
	2000	15.4	35	47	68	4.9	15.3	35	43	66	4.7	15.3	34	41	65	4.5
	1900															
11500	2500	18.5	57	85	104	7.7	18.4	56	84	104	7.5	18.0	53	82	104	7.0
(18° F)	2400	17.4	51	81	99	6.9	17.2	50	79	99	6.6	17.3	49	75	97	6.3
(-8° C)	2300	16.7	46	74	93	6.2	16.6	45	71	92	5.9	16.6	45	68	90	5.7
	2200	16.1	43	67	87	5.7	15.9	41	64	86	5.3	15.9	40	60	83	5.1
	2100	15.4	38	58	79	5.1	15.6	38	54	77	5.0	15.4	36	51	75	4.7
	2000	15.4	36	43	65	4.9	15.0	34	43	67	4.6					
	1900															

Table A2

TABULATED CRUISE DATA BY RPM (Page 21 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis: *RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP	

Altitude	RPM	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
12000 (16° F) (-9° C)	2500															
	2400	17.6	56	87	101	8.0	17.7	55	85	101	7.7	17.5	53	82	99	7.3
	2300	16.6	49	83	96	7.0	16.6	48	79	95	6.7	16.5	47	76	94	6.4
	2200	15.9	45	75	89	6.4	15.9	44	72	88	6.1	15.9	43	69	87	5.8
	2100	15.4	40	67	82	5.9	15.4	40	64	81	5.6	15.1	38	61	81	5.3
	2000	14.8	36	58	75	5.4	14.9	36	53	72	5.2	15.0	36	50	71	5.0
	1900	14.6	33	41	60	5.0	14.6	33	43	63	4.9					
12500 (14° F) (-10° C)	2500															
	2400	17.3	55	86	101	7.9	17.2	53	83	100	7.5	17.2	52	80	99	7.2
	2300	16.3	49	81	96	6.9	16.3	48	77	94	6.6	16.3	47	74	93	6.3
	2200	15.7	44	74	89	6.3	15.7	43	71	88	6.0	15.7	43	67	87	5.8
	2100	15.3	41	67	83	5.9	15.2	40	63	81	5.6	15.0	38	58	79	5.2
	2000	14.5	35	58	75	5.3	15.4	38	41	62	5.4	14.9	35	43	65	4.9
	1900	14.5	34	41	61	5.1	14.1	31	43	64	4.6					
13000 (13° F) (-11° C)	2400	17.3	55	85	101	8.0	16.9	52	82	100	7.3	16.8	50	80	99	7.0
	2300	16.2	48	79	95	6.9	16.1	47	76	94	6.5	16.1	46	73	92	6.2
	2200	15.5	44	72	88	6.2	15.6	43	69	87	6.0	15.6	42	66	86	5.7
	2100	14.8	39	65	82	5.7	14.8	38	60	80	5.4	14.8	37	57	79	5.2
	2000	14.6	36	55	74	5.3	14.4	35	50	71	5.0	14.8	36	41	64	4.9
	1900	14.2	33	41	61	4.9										
13500 (11° F) (-12° C)	2400	17.0	54	83	100	7.7	16.6	51	81	100	7.2	16.6	50	78	99	6.9
	2300	16.2	49	78	94	6.9	15.9	46	74	93	6.4	15.9	45	71	92	6.1
	2200	15.3	43	71	88	6.1	15.4	43	67	87	5.9	15.1	41	64	85	5.5
	2100	14.8	40	63	81	5.7	14.6	38	59	80	5.3	14.6	37	55	78	5.1
	2000	14.9	38	41	62	5.4	14.3	35	47	69	5.0	14.3	34	43	67	4.7

Table A2

TABULATED CRUISE DATA BY RPM (Page 22 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

		60° F (16° C)					80° F (27° C)					100° F (38° C)				
Altitude	RPM	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
12000 (16° F) (-9° C)	2500	18.1	56	83	103	7.5	18.1	55	81	103	7.3	18.0	54	79	103	7.0
	2400	17.3	51	79	99	6.9	17.1	49	76	98	6.5	17.1	48	74	97	6.3
	2300	16.5	46	72	92	6.1	16.5	45	69	91	5.8	16.2	43	68	91	5.5
	2200	15.7	41	66	86	5.5	15.9	41	62	84	5.4	15.8	40	58	82	5.1
	2100	15.3	38	55	77	5.1	15.3	37	51	75	4.9	15.4	37	46	71	4.7
	2000	15.0	35	43	66	4.8										
	1900															
12500 (14° F) (-10° C)	2500						17.7	53	79	102	7.1	17.7	52	77	102	6.8
	2400	17.0	50	78	98	6.8	16.8	48	76	98	6.4	16.8	48	72	96	6.2
	2300	16.3	46	71	91	6.0	16.3	45	68	91	5.8	16.0	43	66	91	5.5
	2200	15.5	41	64	85	5.4	15.6	40	59	83	5.2	15.5	39	56	82	5.0
	2100	15.2	38	54	77	5.1	15.0	36	50	75	4.8	15.5	38	41	67	4.8
	2000	14.9	35	43	67	4.8										
	1900															
13000 (13° F) (-11° C)	2400	16.8	50	76	97	6.7	16.8	49	74	97	6.5	16.7	48	71	96	6.2
	2300	16.1	45	70	92	6.0	16.1	44	67	90	5.7	15.9	42	63	89	5.4
	2200	15.3	40	62	85	5.4	15.4	40	57	82	5.2	15.6	40	55	81	5.1
	2100	15.7	40	41	65	5.3	14.9	36	47	72	4.8	14.9	36	43	70	4.6
	2000	14.3	33	43	67	4.5										
	1900															
13500 (11° F) (-12° C)	2400	16.5	49	75	97	6.6	16.4	47	72	96	6.3	16.5	47	69	95	6.1
	2300	15.8	44	68	90	5.9	15.9	44	65	90	5.7	15.7	42	61	88	5.4
	2200	15.3	41	60	84	5.4	15.2	39	56	82	5.1	15.2	39	51	79	4.9
	2100	15.3	39	41	66	5.1	14.9	37	43	69	4.8	14.9	36	43	70	4.6
	2000															

Table A2

TABULATED CRUISE DATA BY RPM (Page 23 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs	Data Basis:	*RPM* Model
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP		

Altitude	RPM	0° F (-18° C)					20° F (-7° C)					40° F (4° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
14000	2400	16.6	52	81	99	7.5	16.6	51	79	98	7.2	16.6	50	77	98	7.0
(9° F)	2300	15.7	47	76	94	6.7	15.6	45	74	93	6.3	15.7	45	70	91	6.1
(-13° C)	2200	15.2	43	69	87	6.1	14.9	41	67	87	5.7	15.1	41	62	85	5.6
	2100	14.7	39	61	80	5.6	14.4	37	57	79	5.3	15.3	40	41	65	5.3
	2000	14.7	37	41	63	5.4	14.2	35	43	66	4.9					
14500	2400						16.2	50	77	97	7.0	16.2	49	74	97	6.7
(7° F)	2300	15.8	48	75	94	6.8	15.7	46	72	93	6.4	15.5	44	68	90	6.0
(-14° C)	2200	15.0	42	67	86	6.0	14.7	40	65	86	5.6	15.0	41	60	84	5.5
	2100	14.2	38	59	80	5.4	14.3	37	55	78	5.2	15.0	39	41	66	5.2
	2000	14.4	37	41	63	5.3	13.9	34	43	67	4.8					
15000	2400											15.9	47	72	95	6.5
(5° F)	2300	15.5	47	73	93	6.6	15.4	45	70	91	6.2	15.2	43	67	91	5.9
(-15° C)	2200	14.6	41	67	87	5.8	14.6	40	62	85	5.6	14.7	40	57	82	5.4
	2100	14.2	38	56	78	5.4	14.2	37	52	75	5.2	14.5	38	43	69	5.1
	2000	14.1	36	41	64	5.2	13.6	33	43	67	4.7					
15500	2300	15.1	45	72	92	6.4	15.2	45	68	91	6.2	15.1	44	64	89	5.9
(4° F)	2200	14.6	42	64	85	5.9	14.4	40	60	84	5.5	14.5	39	55	81	5.3
(-16° C)	2100	14.1	38	53	76	5.4	14.0	36	50	75	5.1	14.3	37	41	67	5.0
	2000	13.8	35	41	64	5.0	13.3	32	43	68	4.6					
16000	2300	14.9	45	71	92	6.3	14.8	43	67	90	6.0	14.8	42	63	89	5.7
(2° F)	2200	14.5	41	62	85	5.8	14.3	40	57	82	5.5	14.4	39	52	79	5.3
(-17° C)	2100	14.0	37	50	74	5.3	13.9	36	43	69	5.0					
	2000	13.5	34	41	65	4.9										

Table A2

TABULATED CRUISE DATA BY RPM (Page 24 of 24)

USAFA CCFT Cessna 150/150 HP

Engine:	Lycoming O-320-E2D	Mixture:	Leaned	Weight:	1760 lbs
Propeller:	McCauley TM7458/1C172	Carb Heat:	OFF	Flaps:	UP

Data Basis: *RPM* Model

Altitude	RPM	60° F (16° C)					80° F (27° C)					100° F (38° C)				
		MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH	MAP	%BHP	KIAS	KTAS	GPH
14000	2400	16.2	47	74	98	6.4	16.1	46	71	96	6.2	16.2	46	67	94	5.9
(9° F)	2300	15.7	44	66	90	5.8	15.6	43	62	88	5.6	15.4	41	60	88	5.3
(-13° C)	2200	15.0	40	57	82	5.3	15.2	40	54	81	5.2	15.2	39	47	75	4.9
	2100	14.8	37	43	69	5.0	14.8	37	43	70	4.8	14.3	34	43	71	4.4
	2000															
14500	2400	16.2	48	72	96	6.5	16.2	47	69	95	6.2	16.2	46	66	94	6
(7° F)	2300	15.3	43	65	90	5.7	15.5	43	61	88	5.6	15.4	42	57	86	5.3
(-14° C)	2200	14.8	39	56	82	5.2	14.9	39	51	78	5.0	15.2	39	43	72	4.9
	2100	14.5	36	43	69	4.9	14.5	36	43	71	4.7					
	2000															
15000	2400	15.8	47	69	94	6.2	15.8	46	66	93	6.0	15.8	45	62	92	5.8
(5° F)	2300	15.1	42	63	89	5.6	15.1	41	59	88	5.4					
(-15° C)	2200	14.8	39	52	79	5.2	14.9	39	47	75	5.0	14.9	38	43	73	4.8
	2100	14.2	36	43	70	4.7										
	2000															
15500	2300	15.1	43	60	87	5.6	15.1	42	56	85	5.4	15.1	41	51	82	5.2
(4° F)	2200	14.5	39	50	78	5.1	14.8	39	43	72	5.0	14.5	37	43	73	4.7
(-16° C)	2100															
	2000															
16000	2300	14.8	42	58	87	5.5	14.8	41	55	85	5.3					
(2° F)	2200	14.5	39	46	75	5.1	14.5	38	43	73	4.9					
(-17° C)	2100															
	2000															

Table A3

MAXIMUM RANGE AIRSPEED

	Method		
Altitude	Thrust Required/Thrust Horsepower Required	Specific Air Range	*RPM* Model Range
Sea Level	56 KIAS (62 KCAS)	73 KIAS (74 KCAS)	65 KIAS (68 KCAS)
10,000 feet	56 KIAS (62 KCAS)	68 KIAS (70 KCAS)	65 KIAS (68 KCAS)

Table A4

RANGE RESULTS BY AIRSPEED

Indicated Airspeed (KIAS)	Altitude (ft)	Dual Range (nm)	Dual Range with 45 minute reserve (nm)	Percentage of Maximum Range	Solo Range (nm)	Solo Range with 45 minute reserve (nm)	Percentage of Maximum Range
65	5,000	308	253	100%	484	429	100%
65	10,000	322	263	100%	506	477	100%
85	5,000	286	218	86%	452	385	90%
85	10,000	287	214	81%	456	383	80%
105	5,000	235	153	60%	367	284	66%
90	10,000	278	202	77%	436	359	75%

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APPENDIX B

FLIGHT MANUAL INPUTS

HAVE FLOW
INTERIM DATA PACKAGE II

Pitot-Static Position Error

KIAS	Aircraft	50	60	70	80	90	100	110	120
KCAS	TH/AW	58	65	71.5	79.5	88	97	108	118
KCAS	SH	54	61	67.5	75.5	84	93	103	113

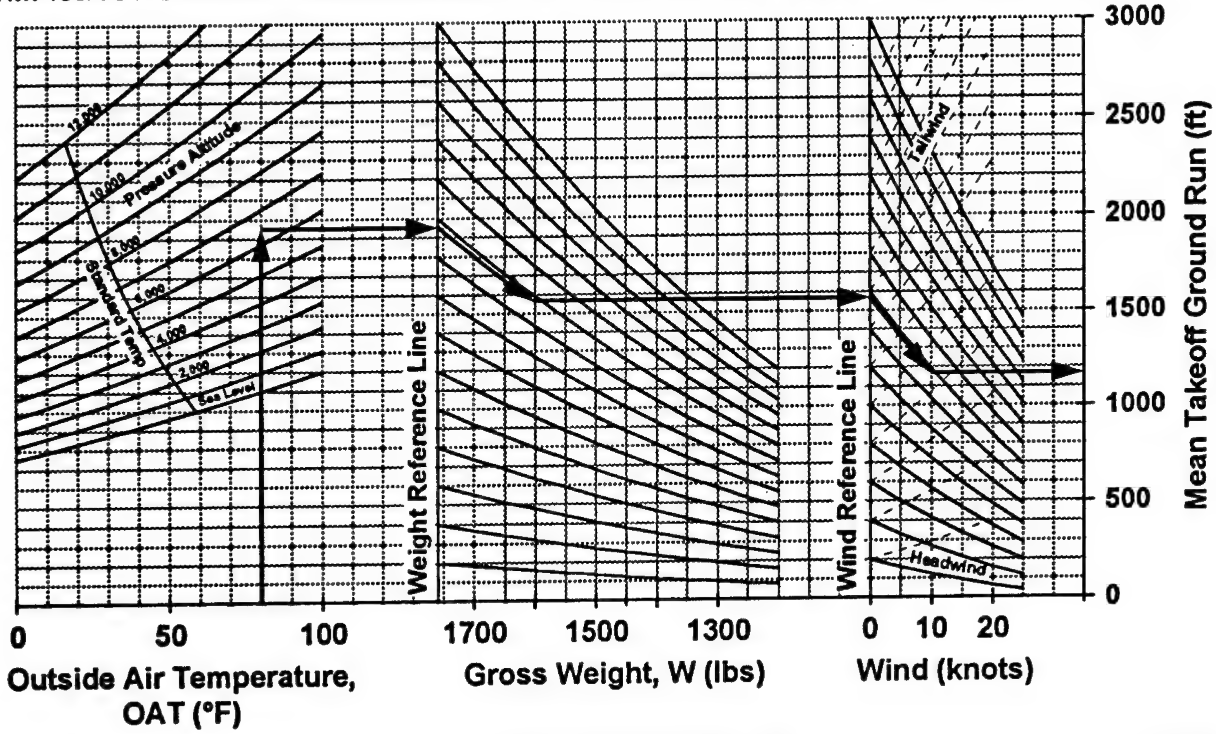
Note: Shaded values **NOT** based on HAVE FLOW Flight Test. These values are estimated based on trends and Flight Manual Data.

Pressure Altitude Conversion Factor

Add the Pressure Altitude Conversion Factor to the altimeter reading to get Pressure Altitude

Altimeter Setting (in Hg)	Pressure Altitude Conversion Factor	Altimeter Setting (in Hg)	Pressure Altitude Conversion Factor
28.00	1824	29.60	298
28.10	1727	29.70	205
28.20	1630	29.80	112
28.30	1533	29.90	20
28.40	1436	29.92	0
28.50	1340	30.00	-73
28.60	1244	30.10	-165
28.70	1148	30.20	-257
28.80	1053	30.30	-348
28.90	957	30.40	-440
29.00	863	30.50	-531
29.10	768	30.60	-622
29.20	673	30.70	-712
29.30	579	30.80	-803
29.40	485	30.90	-893
29.50	392	31.00	-983

Takeoff Data USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned above 5000 ft Carb Heat: OFF Weight: 1760 Flaps: 0%



USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% Shaded Values Exceed 75% Power

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
1000	115 (119	2472	108	12.2	2527	111	12.2	2579	113	12.1	2628	115	12.0	2680	117	12.1			
(55° F	110 (114	2373	104	10.9	2422	106	10.9	2473	108	10.9	2522	110	10.9	2571	112	10.8	2618	114	10.8
(13° C	105 (109	2265	98	9.5	2312	100	9.5	2360	102	9.5	2406	104	9.6	2452	106	9.6	2498	108	9.6
	100 (104	2159	93	8.5	2204	95	8.4	2249	97	8.4	2294	99	8.3	2338	101	8.4	2381	103	8.4
	95 (99)	2074	89	7.8	2117	91	7.7	2161	92	7.6	2204	94	7.6	2246	96	7.5	2288	98	7.5
	90 (94)	1990	84	7.2	2032	86	7.1	2074	88	7.0	2116	90	7.0	2156	91	6.9	2196	93	6.8
	85 (89)	1916	80	6.7	1957	82	6.6	1997	84	6.5	2035	85	6.4	2074	87	6.4	2112	89	6.3
	80 (84)	1842	76	6.3	1881	78	6.2	1921	79	6.1	1959	81	6.0	1997	83	5.9	2033	84	5.9
2000	110 (114	2417	105	11.1	2467	108	11.1	2519	110	11.1	2569	112	11.0	2619	114	11.0	2667	116	11.0
(52° F	105 (109	2306	100	9.6	2354	102	9.7	2403	104	9.8	2451	106	9.8	2498	108	9.8	2544	110	9.7
(11° C	100 (104	2198	95	8.6	2243	97	8.5	2290	99	8.5	2335	101	8.5	2380	103	8.6	2423	104	8.6
	95 (99)	2110	90	7.9	2156	92	7.8	2201	94	7.7	2245	96	7.7	2288	98	7.6	2327	100	7.6
	90 (94)	2028	86	7.3	2069	88	7.2	2112	90	7.1	2154	91	7.0	2196	93	6.9	2236	95	6.9
	85 (89)	1949	82	6.7	1991	84	6.7	2033	85	6.6	2072	87	6.5	2112	89	6.4	2150	90	6.3
	80 (84)	1874	78	6.3	1915	79	6.2	1956	81	6.1	1993	83	6.0	2031	84	6.0	2069	86	5.9
	75 (79)	1811	74	6.0	1852	75	5.9	1890	77	5.8	1926	78	5.7	1960	80	5.6	1998	81	5.5

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% Shaded Values Exceed 75% Power

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
1500	110 (114	2395	104	11.0	2445	107	11.0	2496	109	11.0	2546	111	11.0	2595	113	10.9	2642	115	10.9
(54° F	105 (109	2285	99	9.6	2334	101	9.6	2381	103	9.6	2428	105	9.7	2475	107	9.7	2521	109	9.7
(12° C	100 (104	2177	94	8.5	2224	96	8.4	2270	98	8.4	2315	100	8.4	2358	102	8.4	2401	104	8.5
	95 (99)	2092	89	7.8	2136	91	7.7	2181	93	7.7	2224	95	7.6	2267	97	7.6	2310	99	7.6
	90 (94)	2008	85	7.3	2051	87	7.1	2093	89	7.1	2135	91	7.0	2175	92	6.9	2216	94	6.9
	85 (89)	1931	81	6.8	1972	83	6.6	2013	84	6.5	2053	86	6.5	2093	88	6.4	2131	89	6.3
	80 (84)	1858	77	6.3	1898	79	6.2	1936	80	6.1	1975	82	6.0	2015	83	6.0	2049	85	5.9
	75 (79)	1795	73	6.0	1833	75	5.9	1870	76	5.8	1909	78	5.7	1945	79	5.6	1978	81	5.5
2500	110 (114	2439	106	11.2	2492	109	11.3	2543	111	11.2	2593	113	11.1	2644	115	11.1			
(50° F	105 (109	2326	101	9.7	2376	103	9.8	2425	105	9.9	2474	107	9.9	2521	109	9.9	2568	111	9.8
(10° C	100 (104	2218	96	8.6	2264	98	8.6	2310	100	8.5	2357	102	8.6	2402	104	8.7	2446	105	8.7
	95 (99)	2133	91	7.9	2177	93	7.8	2222	95	7.8	2267	97	7.8	2307	99	7.7	2349	101	7.7
	90 (94)	2045	87	7.3	2089	89	7.2	2132	90	7.1	2174	92	7.0	2216	94	7.0	2257	96	7.0
	85 (89)	1969	83	6.8	2009	84	6.7	2051	86	6.6	2092	88	6.5	2131	89	6.4	2170	91	6.4
	80 (84)	1894	78	6.3	1933	80	6.2	1975	82	6.1	2012	83	6.1	2051	85	6.0	2088	86	5.9
	75 (79)	1827	74	6.0	1865	76	5.9	1905	78	5.8	1942	79	5.7	1980	81	5.6	2016	82	5.5

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
3000	110 (114	2462	107	11.3	2514	110	11.4	2566	112	11.3	2618	114	11.2						
(48° F	105 (109	2349	102	9.9	2398	104	10.0	2448	106	10.0	2497	108	10.0	2544	110	9.9	2591	112	9.9
(9° C)	100 (104	2238	96	8.7	2285	99	8.6	2332	101	8.7	2378	103	8.7	2424	104	8.8	2469	106	8.8
	95 (99)	2149	92	7.9	2196	94	7.8	2241	96	7.8	2286	98	7.8	2328	100	7.8	2371	101	7.8
	90 (94)	2065	87	7.3	2108	89	7.2	2152	91	7.1	2195	93	7.1	2237	95	7.0	2280	97	7.0
	85 (89)	1988	83	6.8	2028	85	6.7	2070	87	6.6	2111	89	6.5	2151	90	6.5	2191	92	6.4
	80 (84)	1912	79	6.4	1951	81	6.2	1991	82	6.2	2031	84	6.1	2070	86	6.0	2107	87	5.9
	75 (79)	1844	75	6.0	1882	77	5.9	1923	78	5.8	1961	80	5.7	1996	81	5.6	2033	83	5.6
4000	105 (109	2393	104	10.2	2443	106	10.2	2494	108	10.2	2544	110	10.1	2592	112	10.1	2641	115	10.0
(45° F	100 (104	2280	98	8.8	2327	100	8.8	2376	102	8.9	2424	104	8.9	2470	106	8.9	2515	108	8.9
(7° C)	95 (99)	2190	94	8.0	2237	96	7.9	2281	98	7.9	2327	100	7.9	2371	101	8.0	2415	103	8.0
	90 (94)	2102	89	7.4	2148	91	7.3	2192	93	7.2	2238	95	7.2	2281	97	7.2	2318	98	7.1
	85 (89)	2024	85	6.8	2067	87	6.7	2109	88	6.7	2151	90	6.6	2192	92	6.5	2232	94	6.5
	80 (84)	1947	81	6.4	1987	82	6.3	2029	84	6.2	2069	86	6.1	2109	87	6.0	2147	89	6.0
	75 (79)	1877	76	6.0	1917	78	5.9	1959	80	5.8	1995	81	5.7	2034	83	5.7	2071	84	5.6
	70 (74)	1815	72	5.7	1855	74	5.6	1891	75	5.5	1927	77	5.4	1964	78	5.3	2002	80	5.3

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
3500	105 (109	2366	103	10.0	2420	105	10.1	2471	107	10.1	2520	109	10.1	2568	111	10.0	2616	113	10.0
(47° F	100 (104	2259	97	8.8	2306	99	8.7	2353	101	8.8	2401	103	8.8	2447	105	8.9	2492	107	8.9
(8° C)	95 (99)	2171	93	8.0	2215	95	7.9	2262	97	7.9	2307	99	7.8	2349	101	7.9	2393	102	7.9
	90 (94)	2084	88	7.3	2128	90	7.2	2173	92	7.2	2216	94	7.1	2257	96	7.1	2297	97	7.0
	85 (89)	2006	84	6.8	2047	86	6.7	2090	88	6.6	2131	89	6.6	2172	91	6.5	2211	93	6.4
	80 (84)	1927	80	6.3	1969	81	6.3	2010	83	6.2	2050	85	6.1	2089	86	6.0	2128	88	6.0
	75 (79)	1860	76	6.0	1899	77	5.9	1938	79	5.8	1977	81	5.7	2014	82	5.6	2052	84	5.6
	70 (74)	1798	72	5.7	1836	73	5.6	1877	75	5.5	1914	76	5.4	1947	78	5.3	1984	79	5.3
4500	105 (109	2415	105	10.3	2466	107	10.3	2518	109	10.3	2567	111	10.2	2617	113	10.2			
(43° F	100 (104	2301	99	8.9	2349	101	8.9	2399	103	9.0	2446	105	9.0	2493	107	9.0	2539	109	9.0
(6° C)	95 (99)	2211	95	8.1	2257	97	8.0	2303	99	8.0	2348	101	8.0	2393	102	8.1	2438	104	8.1
	90 (94)	2120	90	7.4	2168	92	7.3	2211	94	7.2	2254	96	7.2	2299	97	7.2	2340	99	7.2
	85 (89)	2040	86	6.8	2085	87	6.8	2129	89	6.7	2171	91	6.6	2213	93	6.6	2253	94	6.5
	80 (84)	1967	81	6.4	2006	83	6.3	2048	85	6.2	2089	86	6.1	2128	88	6.1	2167	90	6.0
	75 (79)	1897	77	6.0	1935	79	5.9	1977	80	5.8	2014	82	5.7	2053	84	5.7	2090	85	5.6
	70 (74)	1832	73	5.7	1870	75	5.6	1908	76	5.5	1945	78	5.4	1983	79	5.3	2019	81	5.3

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
5000	105 (109	2435	106	10.3	2490	108	10.4	2541	110	10.3	2592	112	10.3	2641	115	10.2			
(41° F	100 (104	2323	100	9.0	2372	102	9.1	2421	104	9.1	2469	106	9.1	2516	108	9.1	2563	110	9.0
(5° C)	95 (99)	2230	95	8.1	2277	97	8.1	2324	99	8.1	2370	101	8.1	2416	103	8.2	2461	105	8.2
	90 (94)	2142	91	7.4	2187	93	7.3	2233	95	7.3	2276	97	7.2	2319	98	7.2	2362	100	7.3
	85 (89)	2062	86	6.9	2105	88	6.8	2149	90	6.7	2191	92	6.6	2234	94	6.6	2272	95	6.6
	80 (84)	1983	82	6.4	2025	84	6.3	2067	86	6.2	2108	87	6.2	2148	89	6.1	2188	90	6.0
	75 (79)	1916	78	6.0	1954	80	5.9	1994	81	5.8	2034	83	5.8	2073	84	5.7	2110	86	5.6
	70 (74)	1848	74	5.7	1887	75	5.6	1925	77	5.5	1964	78	5.4	2001	80	5.4	2039	81	5.3
6000	100 (104	2367	102	9.2	2417	104	9.3	2467	106	9.3	2516	108	9.3	2564	110	9.2	2613	112	9.2
(38° F	95 (99)	2272	97	8.2	2321	99	8.2	2370	101	8.3	2416	103	8.3	2463	105	8.4	2508	107	8.4
(3° C)	90 (94)	2184	92	7.5	2228	94	7.4	2274	96	7.4	2319	98	7.4	2363	100	7.4	2407	102	7.5
	85 (89)	2099	88	6.9	2146	90	6.8	2190	92	6.8	2231	94	6.7	2273	95	6.7	2315	97	6.7
	80 (84)	2019	84	6.4	2064	85	6.3	2106	87	6.3	2148	89	6.2	2190	91	6.1	2230	92	6.1
	75 (79)	1951	79	6.0	1991	81	5.9	2032	83	5.9	2073	84	5.8	2111	86	5.7	2151	88	5.7
	70 (74)	1884	75	5.7	1923	77	5.6	1964	78	5.5	2002	80	5.5	2040	81	5.4	2078	83	5.3
	65 (69)	1835	72	5.5	1871	73	5.4	1910	75	5.3	1950	76	5.2	1985	78	5.1	2022	79	5.1

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
5500	100 (104	2345	101	9.1	2395	103	9.2	2444	105	9.2	2492	107	9.2	2540	109	9.2	2587	111	9.1
(39° F	95 (99)	2252	96	8.2	2299	98	8.1	2346	100	8.2	2394	102	8.2	2440	104	8.3	2484	106	8.3
(4° C)	90 (94)	2162	92	7.4	2209	94	7.4	2254	96	7.3	2297	97	7.3	2341	99	7.3	2384	101	7.4
	85 (89)	2081	87	6.9	2125	89	6.8	2169	91	6.7	2214	93	6.7	2256	94	6.7	2293	96	6.6
	80 (84)	2001	83	6.4	2044	85	6.3	2086	86	6.2	2128	88	6.2	2169	90	6.1	2211	91	6.1
	75 (79)	1931	79	6.0	1972	80	5.9	2013	82	5.9	2053	84	5.8	2092	85	5.7	2130	87	5.7
	70 (74)	1865	74	5.7	1904	76	5.6	1944	78	5.5	1984	79	5.4	2020	81	5.4	2058	82	5.3
	65 (69)	1818	71	5.5	1855	73	5.4	1892	74	5.3	1932	76	5.2	1966	77	5.1	2002	78	5.1
6500	100 (104	2390	103	9.4	2440	105	9.4	2491	107	9.4	2540	109	9.4	2590	111	9.3			
(36° F	95 (99)	2296	98	8.3	2343	100	8.3	2392	102	8.4	2439	104	8.4	2486	106	8.4	2532	108	8.4
(2° C)	90 (94)	2202	93	7.5	2249	95	7.5	2296	97	7.4	2341	99	7.5	2386	101	7.5	2430	103	7.6
	85 (89)	2119	89	6.9	2163	91	6.8	2208	93	6.8	2252	94	6.7	2295	96	6.7	2337	98	6.8
	80 (84)	2040	84	6.5	2083	86	6.4	2127	88	6.3	2169	90	6.2	2210	91	6.2	2248	93	6.1
	75 (79)	1969	80	6.1	2010	82	6.0	2052	84	5.9	2092	85	5.8	2132	87	5.8	2172	88	5.7
	70 (74)	1900	76	5.7	1940	78	5.6	1982	79	5.5	2021	81	5.5	2060	82	5.4	2098	84	5.4
	65 (69)	1849	72	5.5	1890	74	5.4	1928	76	5.3	1966	77	5.2	2005	78	5.2	2041	80	5.1

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
7000	100 (104	2410	104	9.4	2464	106	9.5	2514	108	9.5	2564	110	9.4						
(34° F	95 (99)	2317	99	8.4	2366	101	8.4	2415	103	8.5	2463	105	8.5	2510	107	8.5	2556	109	8.5
(1° C)	90 (94)	2225	94	7.6	2270	96	7.5	2317	98	7.5	2363	100	7.6	2409	102	7.6	2454	104	7.6
	85 (89)	2138	90	7.0	2184	92	6.9	2229	94	6.8	2273	95	6.8	2317	97	6.8	2359	99	6.8
	80 (84)	2059	85	6.5	2104	87	6.4	2147	89	6.3	2192	91	6.3	2233	92	6.2	2270	94	6.2
	75 (79)	1987	81	6.1	2029	83	6.0	2071	84	5.9	2112	86	5.8	2152	88	5.8	2192	89	5.7
	70 (74)	1918	77	5.7	1960	78	5.6	2000	80	5.6	2040	81	5.5	2080	83	5.4	2117	85	5.4
	65 (69)	1868	73	5.5	1907	75	5.4	1947	76	5.3	1986	78	5.2	2024	79	5.2	2062	81	5.1
8000	95 (99)	2362	101	8.6	2411	103	8.7	2462	105	8.7	2510	107	8.7	2559	109	8.6	2605	111	8.6
(30° F	90 (94)	2267	96	7.7	2314	98	7.7	2363	100	7.7	2410	102	7.8	2456	104	7.8	2501	106	7.8
(-1° C)	85 (89)	2179	91	7.0	2226	93	7.0	2272	95	6.9	2317	97	6.9	2362	99	7.0	2406	101	7.0
	80 (84)	2098	87	6.5	2143	89	6.4	2186	90	6.3	2229	92	6.3	2272	94	6.3	2314	96	6.3
	75 (79)	2026	82	6.1	2069	84	6.0	2111	86	5.9	2153	88	5.9	2192	89	5.8	2232	91	5.8
	70 (74)	1958	78	5.8	1998	80	5.7	2039	81	5.6	2080	83	5.5	2120	85	5.5	2162	86	5.4
	65 (69)	1902	75	5.5	1945	76	5.4	1985	78	5.3	2024	79	5.3	2063	81	5.2	2101	82	5.2
	60 (64)	1857	71	5.3	1897	73	5.2	1935	74	5.1	1974	75	5.1	2012	77	5.0	2049	78	5.0

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
7500	95 (99)	2339	100	8.5	2388	102	8.6	2438	104	8.6	2486	106	8.6	2534	108	8.6	2582	110	8.5
(32° F	90 (94)	2247	95	7.6	2292	97	7.6	2339	99	7.6	2387	101	7.7	2432	103	7.7	2477	105	7.7
(0° C)	85 (89)	2162	91	7.0	2205	93	6.9	2250	94	6.9	2295	96	6.9	2339	98	6.9	2382	100	6.9
	80 (84)	2078	86	6.5	2124	88	6.4	2165	90	6.3	2208	91	6.3	2250	93	6.2	2291	95	6.2
	75 (79)	2007	82	6.1	2049	83	6.0	2091	85	5.9	2133	87	5.9	2176	88	5.8	2215	90	5.8
	70 (74)	1940	77	5.7	1979	79	5.6	2020	81	5.6	2060	82	5.5	2099	84	5.4	2138	85	5.4
	65 (69)	1887	74	5.5	1926	75	5.4	1966	77	5.3	2005	78	5.3	2044	80	5.2	2081	81	5.1
	60 (64)	1838	70	5.3	1878	72	5.2	1916	73	5.1	1955	75	5.0	1992	76	5.0	2029	78	4.9
8500	95 (99)	2382	102	8.7	2435	104	8.8	2485	106	8.8	2536	108	8.8	2582	110	8.7			
(29° F	90 (94)	2289	97	7.8	2337	99	7.8	2386	101	7.8	2433	103	7.9	2479	105	7.9	2525	107	7.9
(-2° C)	85 (89)	2201	92	7.1	2247	94	7.0	2294	96	7.0	2339	98	7.0	2385	100	7.1	2429	102	7.1
	80 (84)	2120	88	6.5	2162	90	6.4	2207	91	6.4	2251	93	6.4	2293	95	6.3	2336	97	6.4
	75 (79)	2045	83	6.1	2089	85	6.0	2132	87	6.0	2172	88	5.9	2212	90	5.8	2254	92	5.8
	70 (74)	1977	79	5.8	2018	81	5.7	2059	82	5.6	2100	84	5.6	2143	85	5.5	2182	87	5.5
	65 (69)	1922	75	5.5	1964	77	5.4	2005	78	5.4	2044	80	5.3	2083	82	5.2	2121	83	5.2
	60 (64)	1876	72	5.3	1915	73	5.2	1955	75	5.1	1993	76	5.1	2032	78	5.0	2069	79	5.0

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
9000	95 (99)	2407	103	8.9	2458	105	8.9	2510	107	8.9	2558	109	8.8						
(27° F	90 (94)	2311	98	7.8	2360	100	7.9	2409	102	7.9	2456	104	8.0	2504	106	8.0	2551	108	7.9
(-3° C)	85 (89)	2225	93	7.1	2269	95	7.1	2316	97	7.1	2363	99	7.1	2408	101	7.2	2452	103	7.2
	80 (84)	2141	88	6.6	2183	90	6.5	2228	92	6.4	2273	94	6.4	2316	96	6.4	2359	98	6.5
	75 (79)	2064	84	6.1	2109	86	6.1	2150	88	6.0	2192	89	5.9	2234	91	5.9	2276	93	5.9
	70 (74)	1992	80	5.8	2037	81	5.7	2079	83	5.6	2121	85	5.6	2163	86	5.5	2202	88	5.5
	65 (69)	1943	76	5.5	1983	78	5.4	2024	79	5.4	2064	81	5.3	2104	82	5.3	2142	84	5.2
	60 (64)	1896	72	5.3	1934	74	5.2	1974	75	5.2	2013	77	5.1	2052	78	5.0	2089	80	5.0
10000	90 (94)	2354	100	8.0	2406	102	8.1	2456	104	8.1	2506	106	8.1	2552	108	8.1			
(23° F	85 (89)	2266	95	7.2	2315	97	7.2	2362	99	7.3	2409	101	7.3	2455	103	7.3	2501	105	7.4
(-5° C)	80 (84)	2180	90	6.6	2226	92	6.6	2272	94	6.5	2317	96	6.5	2362	98	6.6	2406	99	6.6
	75 (79)	2105	86	6.2	2147	87	6.1	2192	89	6.0	2235	91	6.0	2278	93	6.0	2320	95	6.0
	70 (74)	2033	81	5.8	2077	83	5.7	2122	85	5.7	2160	86	5.6	2202	88	5.6	2241	90	5.5
	65 (69)	1981	77	5.6	2022	79	5.5	2064	81	5.4	2107	82	5.4	2147	84	5.3	2186	85	5.3
	60 (64)	1932	74	5.3	1971	75	5.3	2013	77	5.2	2053	78	5.1	2092	80	5.1	2133	81	5.0
	55 (59)	1876	70	5.1	1923	71	5.1	1963	73	5.0	2002	74	4.9	2040	76	4.9	2077	77	4.8

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
9500	90 (94)	2334	99	7.9	2383	101	8.0	2432	103	8.0	2481	105	8.1	2529	107	8.0	2575	109	8.0
(25° F	85 (89)	2246	94	7.2	2291	96	7.1	2340	98	7.2	2386	100	7.2	2432	102	7.3	2476	104	7.3
(-4° C)	80 (84)	2158	89	6.6	2205	91	6.5	2250	93	6.5	2295	95	6.5	2338	97	6.5	2382	99	6.6
	75 (79)	2083	85	6.2	2127	87	6.1	2171	88	6.0	2214	90	6.0	2256	92	5.9	2298	94	5.9
	70 (74)	2014	80	5.8	2057	82	5.7	2102	84	5.7	2143	85	5.6	2184	87	5.6	2220	89	5.5
	65 (69)	1962	77	5.5	2002	78	5.5	2043	80	5.4	2084	82	5.3	2127	83	5.3	2165	85	5.2
	60 (64)	1911	73	5.3	1952	75	5.2	1993	76	5.2	2033	78	5.1	2072	79	5.1	2110	81	5.0
	55 (59)	1866	69	5.1	1907	71	5.1	1943	72	5.0	1982	73	4.9	2020	75	4.9	2057	76	4.8
10500	90 (94)	2379	101	8.2	2430	103	8.2	2481	105	8.2	2528	107	8.2						
(22° F	85 (89)	2289	96	7.3	2337	98	7.3	2386	100	7.4	2433	102	7.4	2480	104	7.4	2526	106	7.4
(-6° C)	80 (84)	2204	91	6.7	2248	93	6.6	2294	95	6.6	2341	97	6.6	2386	99	6.7	2429	100	6.7
	75 (79)	2125	86	6.2	2168	88	6.1	2213	90	6.1	2257	92	6.0	2300	94	6.0	2344	95	6.1
	70 (74)	2050	82	5.8	2095	84	5.7	2138	85	5.7	2180	87	5.6	2222	89	5.6	2263	90	5.6
	65 (69)	1997	78	5.6	2044	80	5.5	2084	82	5.4	2127	83	5.4	2167	85	5.3	2204	86	5.3
	60 (64)	1951	74	5.4	1991	76	5.3	2033	78	5.2	2073	79	5.2	2115	81	5.1	2154	82	5.1
	55 (59)	1901	70	5.1	1942	72	5.1	1982	73	5.0	2021	75	5.0	2060	76	4.9	2101	78	4.9

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
11000	85 (89)	2311	97	7.4	2360	99	7.4	2409	101	7.5	2457	103	7.5	2503	105	7.5			
(20° F	80 (84)	2225	92	6.7	2271	94	6.7	2318	96	6.7	2364	98	6.7	2409	100	6.8	2453	101	6.8
(-7° C)	75 (79)	2144	87	6.2	2190	89	6.2	2235	91	6.1	2279	93	6.1	2324	95	6.1	2367	96	6.2
	70 (74)	2073	83	5.9	2116	84	5.8	2159	86	5.7	2202	88	5.7	2244	90	5.6	2286	91	5.6
	65 (69)	2019	79	5.6	2065	81	5.5	2107	82	5.5	2144	84	5.4	2184	86	5.3	2225	87	5.3
	60 (64)	1970	75	5.4	2011	77	5.3	2052	78	5.2	2096	80	5.2	2135	81	5.1	2170	83	5.1
	55 (59)	1918	71	5.1	1961	73	5.1	2001	74	5.0	2042	76	5.0	2084	77	4.9	2121	78	4.9
	50 (54)	1879	67	5.0	1921	68	5.0	1960	70	4.9	1999	71	4.8	2037	73	4.8	2075	74	4.7
12000	85 (89)	2357	99	7.6	2407	101	7.6	2459	103	7.7									
(16° F	80 (84)	2268	94	6.8	2316	96	6.8	2364	98	6.9	2411	100	6.9	2459	102	7.0	2504	103	7.0
(-9° C)	75 (79)	2187	89	6.3	2233	91	6.2	2281	93	6.2	2326	95	6.3	2371	96	6.3	2414	98	6.3
	70 (74)	2116	84	5.9	2158	86	5.8	2202	88	5.8	2246	90	5.7	2290	91	5.7	2332	93	5.8
	65 (69)	2057	81	5.6	2101	82	5.5	2144	84	5.5	2186	86	5.4	2228	87	5.4	2269	89	5.4
	60 (64)	2009	77	5.4	2054	78	5.4	2091	80	5.2	2132	82	5.2	2173	83	5.1	2213	85	5.1
	55 (59)	1960	72	5.2	2001	74	5.1	2045	76	5.1	2085	77	5.0	2120	79	4.9	2158	80	4.9
	50 (54)	1917	68	5.0	1959	70	5.0	1999	71	4.9	2042	73	4.9	2081	74	4.8	2119	75	4.8

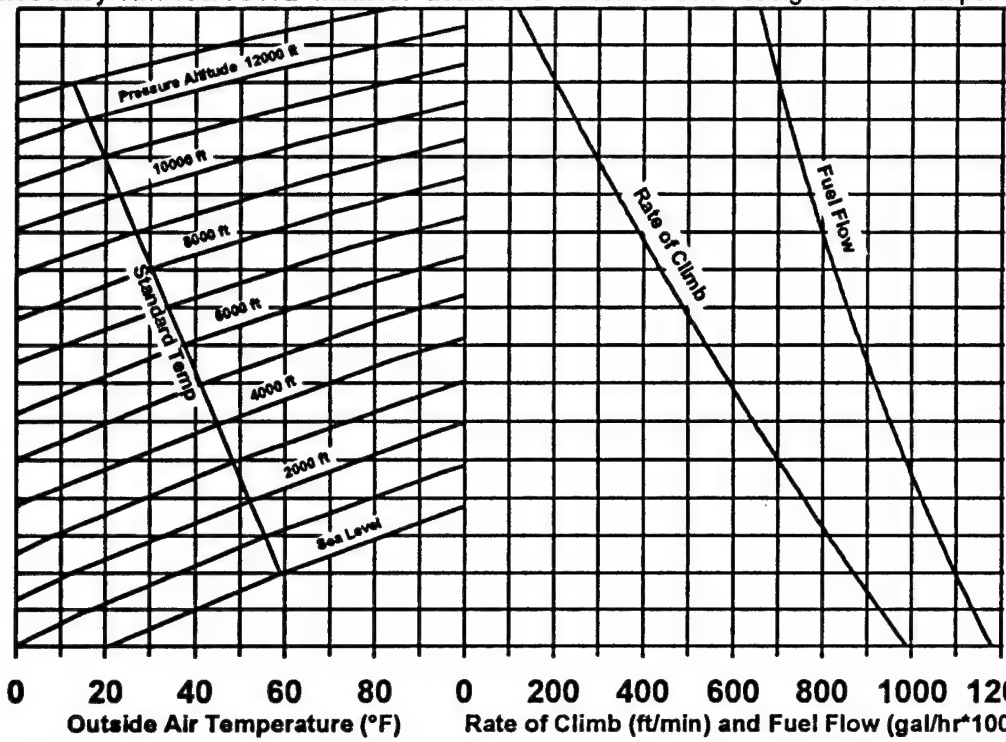
HAVE FLOW **PERFORMANCE DATA** **5/23/96**

USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172
Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0% **Shaded Values Exceed 75% Power**

Pressur Altitude (Std Temp	KIAS TH-AW (SH)	0° F (-18° C)			20° F (-7° C)			40° F (4° C)			60° F (16° C)			80° F (27° C)			100° F (38° C		
		RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH	RPM	KTAS	GPH
11500	85 (89)	2331	98	7.4	2384	100	7.5	2433	102	7.6	2483	104	7.6						
(18° F	80 (84)	2244	93	6.8	2293	95	6.7	2341	97	6.8	2387	99	6.8	2433	101	6.9	2480	102	6.9
(-8° C)	75 (79)	2168	88	6.3	2211	90	6.2	2257	92	6.2	2303	94	6.2	2347	96	6.2	2390	97	6.3
	70 (74)	2092	84	5.9	2136	85	5.8	2180	87	5.7	2224	89	5.7	2266	90	5.7	2307	92	5.7
	65 (69)	2039	80	5.6	2080	81	5.5	2122	83	5.5	2164	85	5.4	2206	86	5.4	2247	88	5.3
	60 (64)	1987	76	5.4	2034	78	5.3	2075	79	5.3	2116	81	5.2	2152	82	5.1	2191	84	5.1
	55 (59)	1942	72	5.2	1981	73	5.1	2022	75	5.1	2065	76	5.0	2104	78	5.0	2142	79	4.9
	50 (54)	1897	68	5.0	1940	69	5.0	1979	70	4.9	2019	72	4.9	2061	73	4.8	2099	75	4.8
12500	80 (84)	2291	95	6.9	2339	97	6.9	2388	99	7.0	2437	101	7.0	2483	103	7.0			
(14° F	75 (79)	2209	90	6.3	2257	92	6.3	2303	94	6.3	2349	96	6.3	2394	97	6.4	2438	99	6.4
(-10° C	70 (74)	2133	85	5.9	2179	87	5.8	2224	89	5.8	2269	91	5.8	2313	92	5.8	2355	94	5.8
	65 (69)	2079	81	5.6	2121	83	5.6	2165	85	5.5	2208	86	5.5	2250	88	5.5	2293	90	5.4
	60 (64)	2028	77	5.4	2069	79	5.3	2111	81	5.3	2153	82	5.2	2194	84	5.2	2235	85	5.2
	55 (59)	1977	73	5.2	2018	75	5.1	2059	76	5.1	2101	78	5.0	2140	79	5.0	2180	81	4.9
	50 (54)	1939	69	5.1	1982	70	5.0	2019	72	4.9	2062	73	4.9	2101	75	4.9	2135	76	4.8
	45 (49)	1903	64	5.0	1945	66	4.9	1986	67	4.8	2028	68	4.8	2066	70	4.8	2103	71	4.7

HAVE FLOW **PERFORMANCE DATA** **5/23/96**

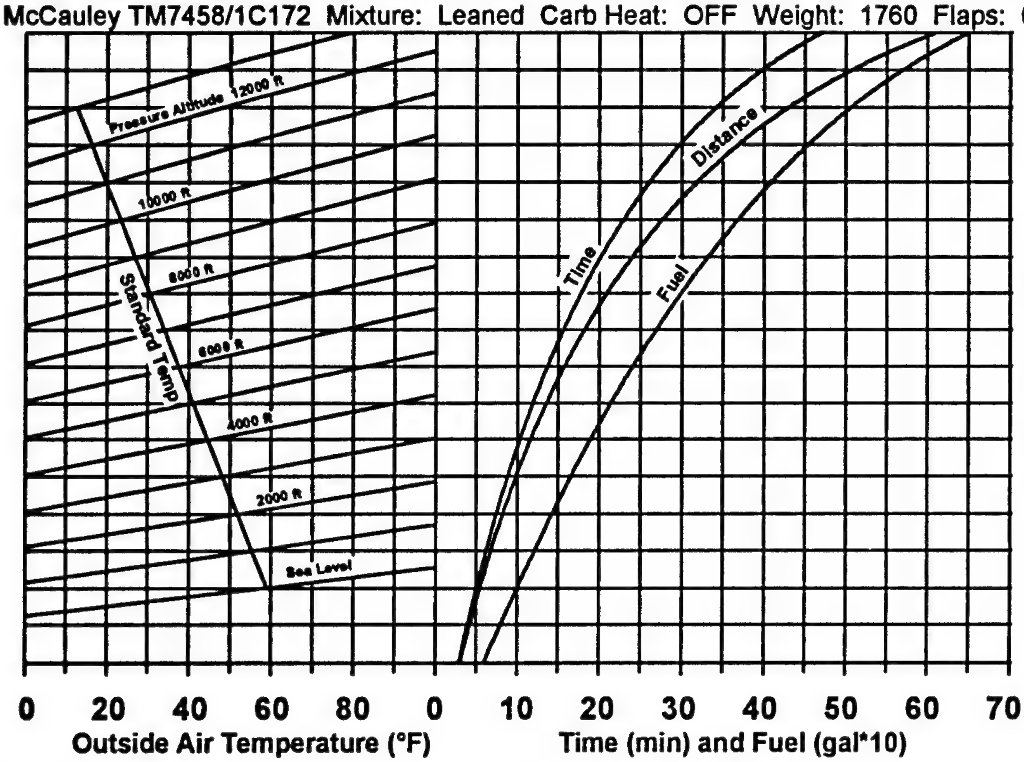
Climb Data at 65 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Climb 65 KIAS

HAVE FLOW PERFORMANCE DATA 6/4/96

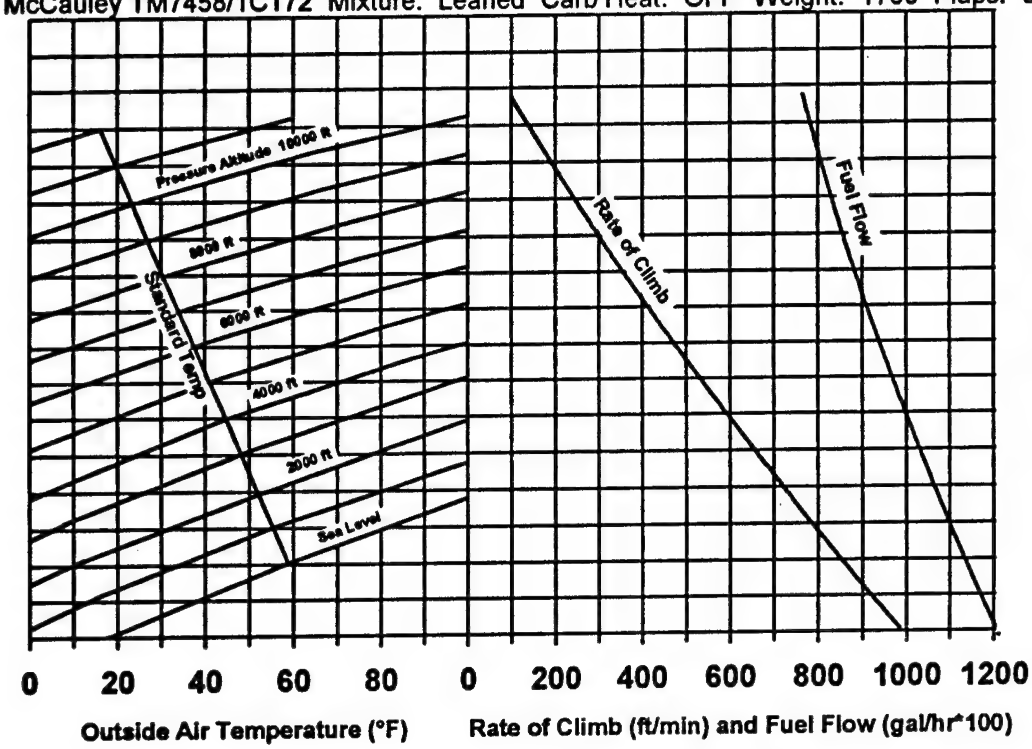
Climb Data at 65 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Climb 65 KIAS

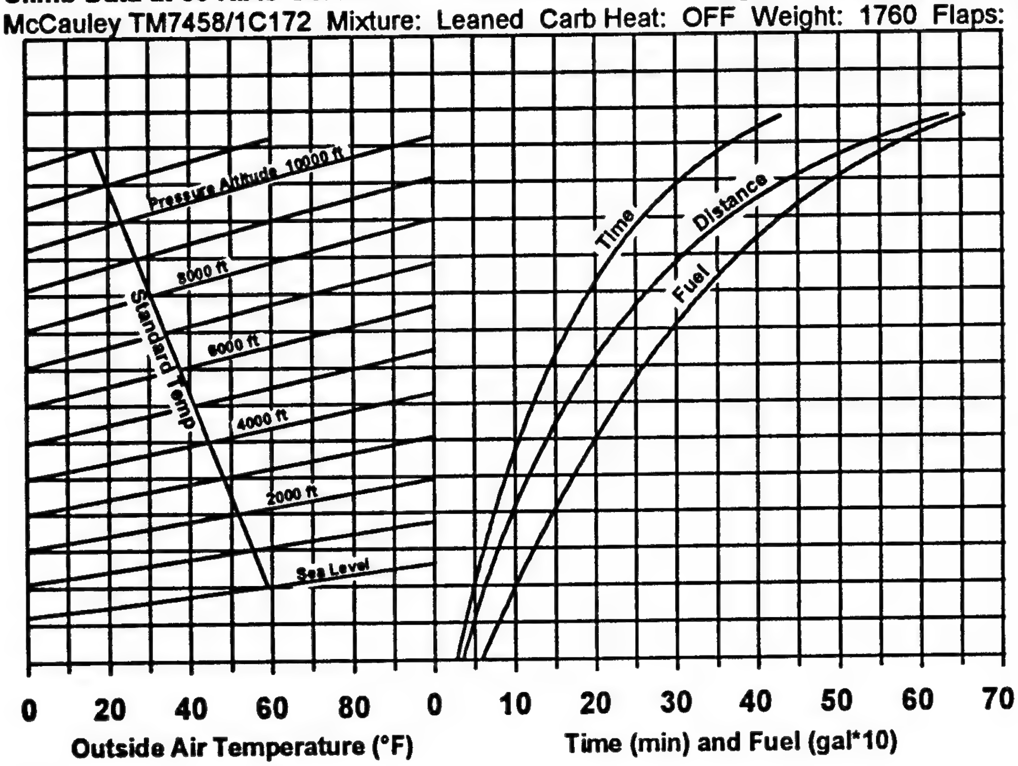
HAVE FLOW PERFORMANCE DATA 6/4/96

Climb Data at 80 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



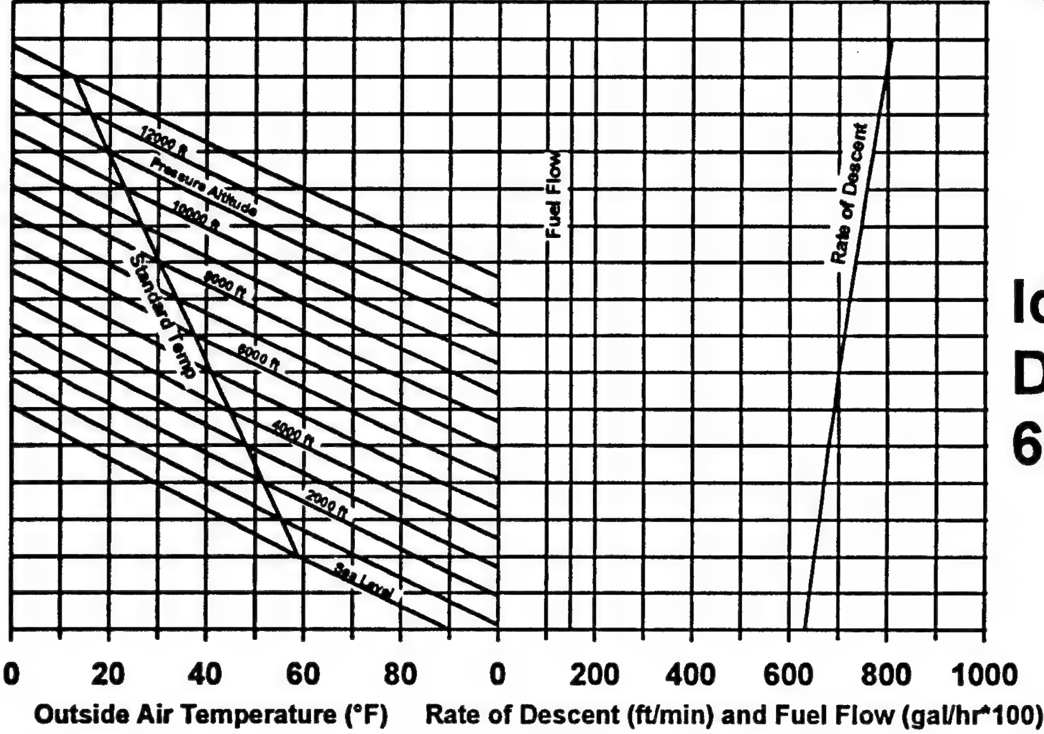
Climb 80 KIAS

Climb Data at 80 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Climb 80 KIAS

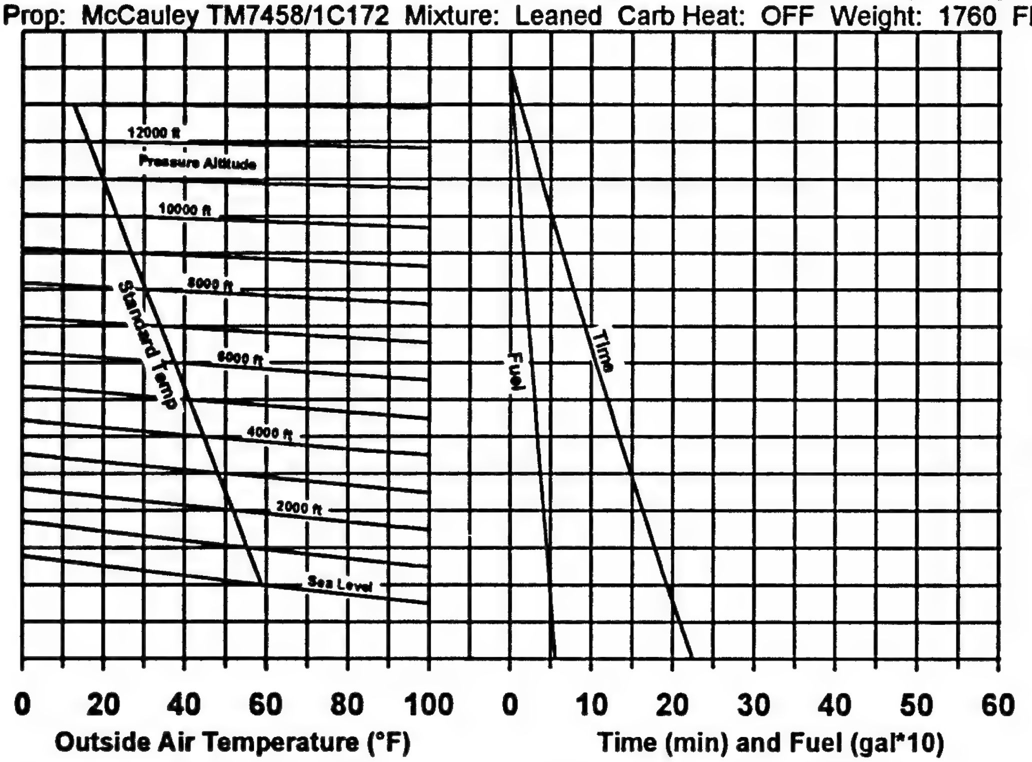
Idle Descent Data at 65 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D
Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Idle Descent 65 KIAS

HAVE FLOW PERFORMANCE DATA 6/4/96

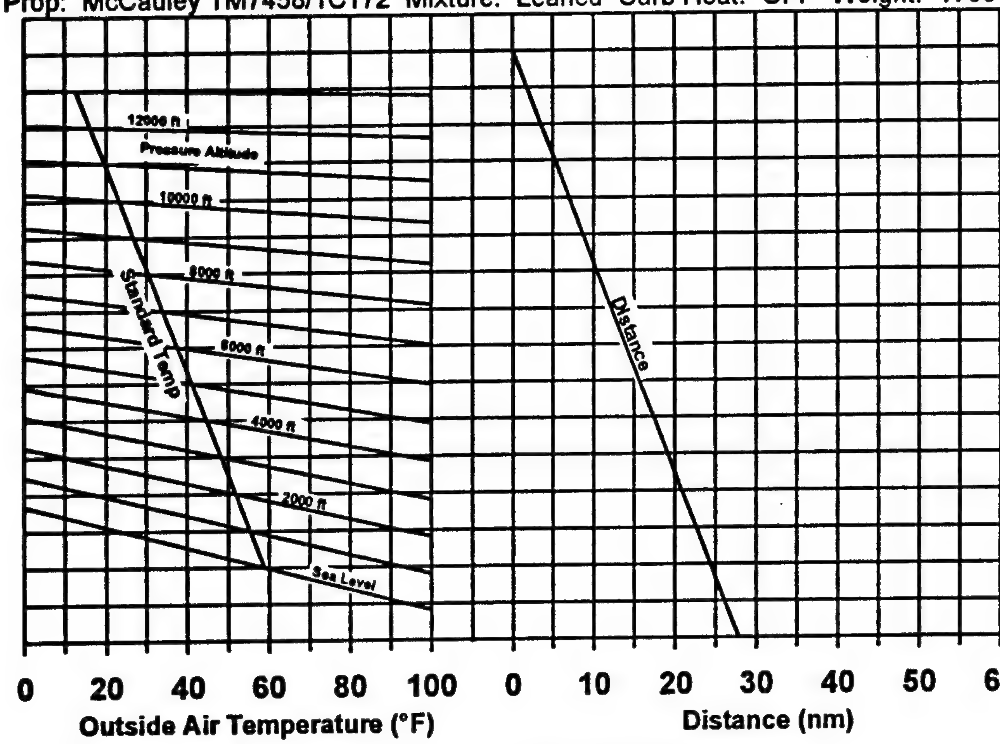
Idle Descent Data at 65 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D
Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Idle Descent 65 KIAS

HAVE FLOW PERFORMANCE DATA 6/4/96

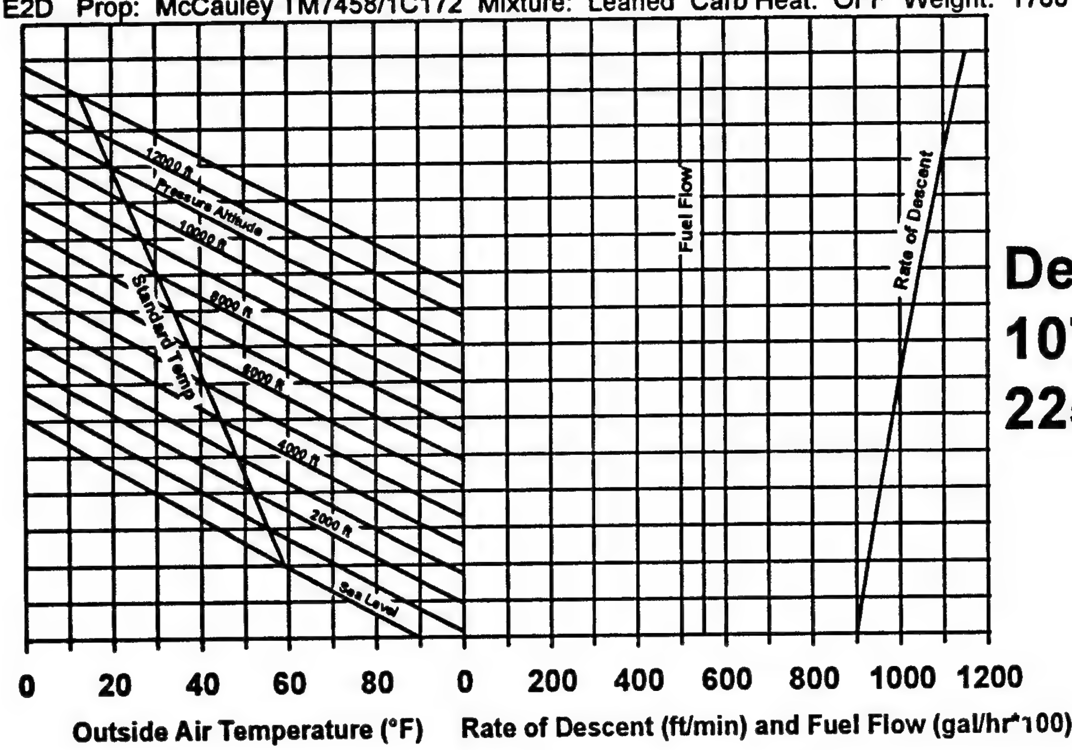
Idle Descent Data at 65 KIAS USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Idle Descent 65 KIAS

HAVE FLOW **PERFORMANCE DATA** 6/4/96

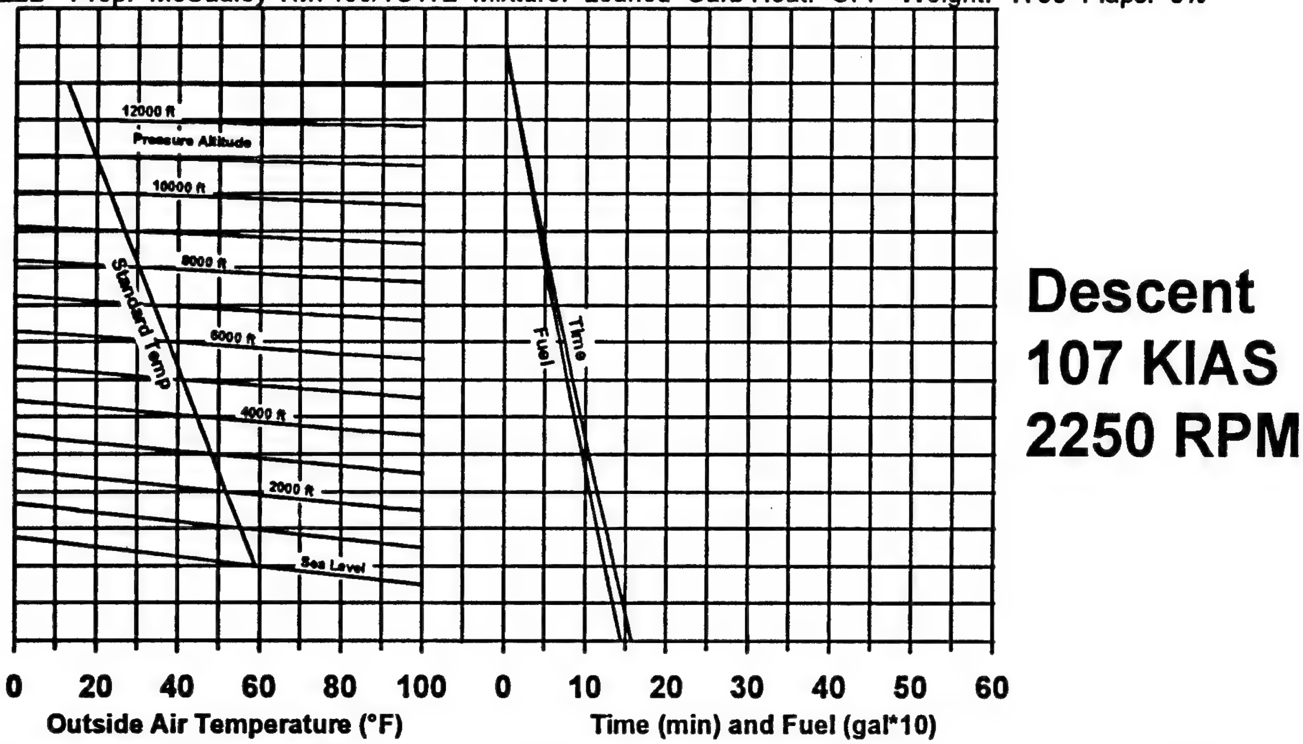
Descent Data at 107 KIAS/2250 RPM USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



Descent 107 KIAS 2250 RPM

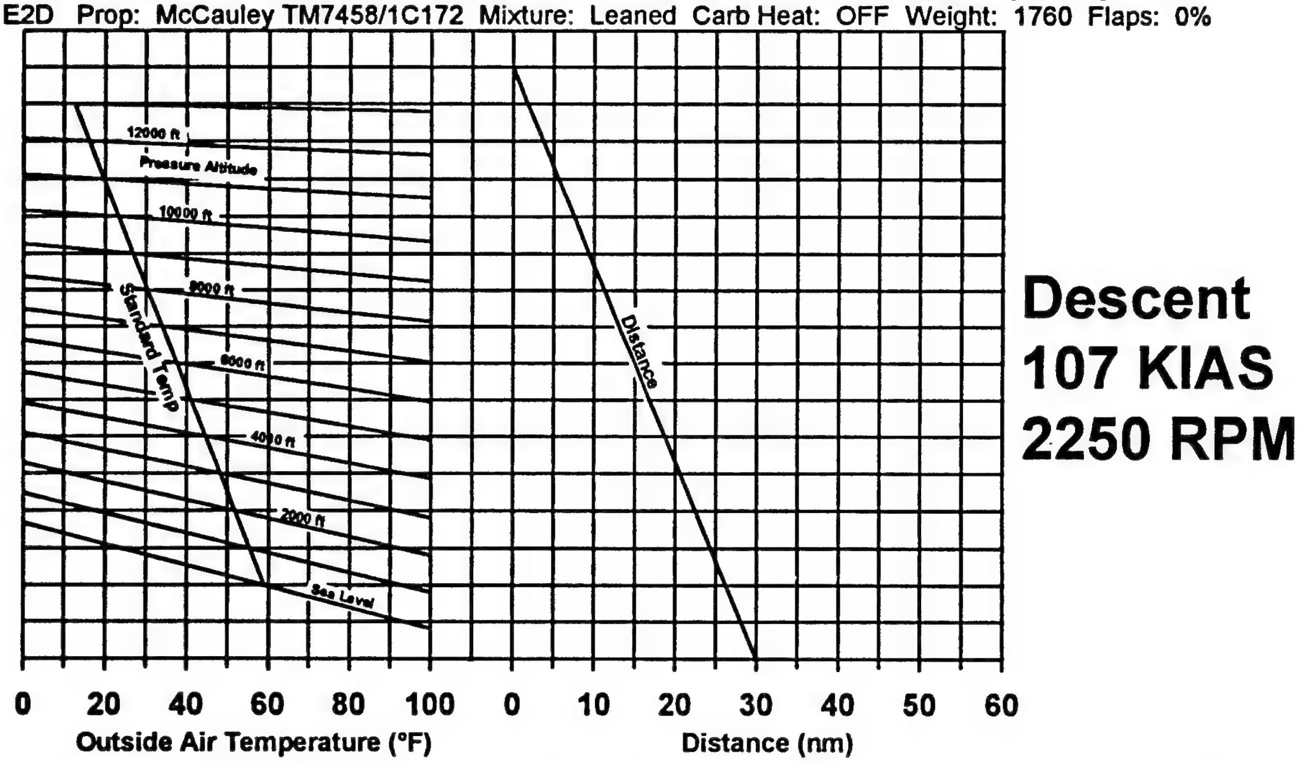
HAVE FLOW **PERFORMANCE DATA** 6/4/96

Descent Data at 107 KIAS/2250 RPM USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



HAVE FLOW **PERFORMANCE DATA** *6/4/96*

Descent Data at 107 KIAS/2250 RPM USAFA CCFT Cessna 150/150HP Engine: Lycoming O-320-E2D Prop: McCauley TM7458/1C172 Mixture: Leaned Carb Heat: OFF Weight: 1760 Flaps: 0%



HAVE FLOW **PERFORMANCE DATA** *6/4/96*

APPENDIX C

AIRCRAFT MODELING

MATCHING *RPM* MODEL TO FLIGHT TEST DATA

The computer model of the aircraft in the Reciprocating Engine and Propeller Modeling Program (*RPM*) actually consisted of three models; the engine, the propeller, and the aircraft itself. (Reference 2). Figure C1 shows the final engine model used for this investigation. Figure C2 through Figure C5 show the final propeller model used for this investigation. At the end of this appendix, the input files to *RPM* for the aircraft, engine, and propeller models are listed.

Each of these models was adjusted individually to accurately model the entire aircraft performance. The aircraft model was fairly straight forward, being primarily the aircraft drag polar. Finding the proper adjustment for the engine and propeller models was an iterative process. The drag polar was chosen and the propeller and engine models were adjusted to match flight test data. The convergence was fairly quick, as good initial models could be created prior to flight test based on Flight Manual data.

Propeller Model Adjustment:

Initially, the drag polar was derived from flight test data. This drag polar was dependant on the engine model (to find brake horsepower (BHP)) and the propeller model (to find propeller efficiency) used to reduce the data. This drag polar was entered into the aircraft model.

The program was then set up to trim the aircraft for level, unaccelerated flight at a specified airspeed, pressure altitude and outside air temperature. The lift coefficient was calculated for the current weight, and knowing the lift coefficient, the drag coefficient was calculated using the drag polar. Once the drag was known, the thrust required for level unaccelerated flight was calculated. The propeller thrust was a function of the thrust coefficient, air density, RPM, and propeller diameter. (Reference 7) Since the air density and propeller diameter were known, the only variables were thrust coefficient and RPM. For a fixed pitch propeller, thrust coefficient is strictly a function of advance ratio. (Reference 7) Advance ratio is a function of true airspeed, RPM, and propeller diameter. Since the true airspeed was set by the input conditions and propeller diameter was known, for this flight condition the advance ratio has a one to one correspondence with RPM. Since the thrust coefficient has a one to one correspondence with advance ratio, at this flight condition thrust coefficient will have a one to one correspondence with RPM. The RPM was then adjusted until the proper thrust coefficient was found to produce the thrust required.

The inputs to the propeller model were the blade planform shape, number of blades, propeller diameter, and propeller pitch. A helical pitch distribution was assumed. (Reference 2) The only input which could be varied to match flight test data was the propeller pitch. The pitch was adjusted in a similar fashion to the method used to regulate the RPM of a constant speed propeller. With the model stabilized in level, unaccelerated flight at a known flight test airspeed, altitude, and temperature, the value of RPM reported by the model was noted. If the RPM reported was higher than the RPM seen in flight test, the propeller pitch in the propeller model was increased. If the RPM reported was lower than the RPM seen in flight test, the propeller pitch in the propeller model was decreased. This process was repeated for many different cruise flight test points until a satisfactory overall match was made.

Figure C6 shows the final match between flight test recorded RPM and model reported RPM. The difference of model RPM minus flight test RPM is plotted against indicated airspeed. The mean error was -8 RPM, and the 95 percent confidence interval was ±72 RPM. This was considered a satisfactory match, since the 95 percent confidence interval was smaller than ±1 division (100 RPM/division) on the tachometer.

Engine Model Adjustment:

At this point, a second iteration propeller model was in hand. However, to get this propeller model, the engine power output was adjusted as required to generate the power required as specified by the propeller power coefficient. Like the thrust coefficient, the power coeffiecient for a fixed pitch propeller is solely a function of advance ratio. The inputs to the engine model to determine BHP were manifold pressure (MAP), RPM, pressure altitude, and outside air temperature. (Reference 2) The pressure altitude and outside air temperature were set by the conditions for the flight test point. The RPM was set as required by the propeller to produce the correct thrust. The only remaining input to the engine model was the MAP.

Because only MAP remains, the propeller model can be adjusted independant of the engine model. The engine model would produce the BHP required by the propeller. The difference with different engine models would show in the resulting MAP. If the engine model was more powerful than the actual engine, a lower value of MAP would be required by the engine model to produce the required horsepower. If the engine model was less powerful than the actual engine, a higher value of MAP would be required by the engine model to produce the required horsepower.

To adjust the engine model to match the model MAP with the flight test MAP, the "fit coefficient" was varied. Note on the sea level side of Figure C1 (the left side) the different lines of constant RPM. As the fit coefficient was modified, the line of maximum constant RPM (in this case, 2700 RPM) does not change. As the fit coefficient was reduced, the other lines of constant RPM moved up, thus moving closer together. As the fit coefficient was increased, the lines of constant RPM moved down, spreading farther apart. The result of changing the fit coefficient was that for a given BHP (specified by the propeller parameters), a lower fit coefficient resulted in a lower MAP. Likewise, a higher fit coefficient resulted in a higher MAP. Thus, the fit coefficient was adjusted for many different cruise flight test points until a satisfactory overall match was made.

Figure C7 shows the final match between flight test recorded MAP and model reported MAP. The difference of model MAP minus flight test MAP is plotted against RPM. The mean error was -0.12 in Hg, and the 95 percent confidence interval was ±0.98 in Hg. This was considered a satisfactory match, since the 95 percent confidence interval was smaller than ±1 division (1 in Hg/division) on the MAP gauge.

At this point, a second iteration engine model was in hand. However, this engine model was based on the second iteration propeller model and the first iteration drag polar. The new engine and propeller model were incorporated in the data reduction of the original flight test data, and a new second iteration drag polar was found. The next iteration was then started back at "Propeller Model Adjustment." These iterations were continued until the aircraft, propeller, and engine models converged.

Fuel Flow Adjustment:

Although the fuel flow adjustment was made in the engine model, it was considered separately because an accurate adjustment of fuel flow required having a satisfactory prediction of RPM and MAP first.

The fuel flow rate is calculated by multiplying the mixture times the mass flow rate of air. The mass flow rate of air is calculated by (Reference 2)

$$\dot{m}_{air} = \frac{MAP}{R * T} * \frac{RPM}{2} * \text{Displacement} * \eta_{vol}$$

The manifold pressure (MAP), manifold temperature (T), and RPM are already known. R is the gas constant (1716 ft-lb/slug-°R). The displacement is a fixed value for the engine. The remaining factor is the volumetric efficiency (η_{vol}), which is the ratio of the mass of fuel-air mixture drawn into the cylinder on the intake stroke to the mass of fuel-air mixture that would fill the cylinder at the intake manifold density. In other words, it measures how efficiently the cylinder is filled with the fuel-air charge. The volumetric efficiency allows adjustment of the amount of air flowing through the engine, and thus adjustment of the amount of fuel flowing through the engine.

The volumetric efficiency was modeled as a function of RPM. The values of volumetric efficiency were adjusted until the mean error was no longer a function of RPM. The final match between flight test recorded fuel flow and model reported fuel flow is shown in Figure C8. In this figure, the scatter of the data points (difference of model fuel flow minus flight test fuel flow) is evenly distributed about a horzontal line. Once the distribution mean is horizontal, the result is the best possible match. Looking at the air mass flow equation above, the air mass flow is a function of MAP and RPM. Since fuel flow is just the mixture times the air mass flow, fuel flow will also be a function of MAP and RPM. Therefore, any scatter in MAP and RPM (as shown in Figure C6 and Figure C7) will create scatter in the fuel flow prediction. A further improvement of agreement would require improving the MAP agreement and the RPM agreement. The mean error was -0.13 gal/hr, and the 95 percent confidence interval was ±0.89 gal/hr.

Figure C9 presents the fuel flow error in percent. This value was determined by dividing the fuel flow error by the flight test fuel flow reading. The 95

percent confidence interval boundaries are slightly in excess of the ±10 percent error allowed in predicting fuel consumption in competition. However, assuming this error was normally distributed, predicted fuel flows should tend toward actual fuel flows sufficiently within the ±10 percent error band most of the time.

Full Throttle Modeling:

An additional adjustment for the engine model was necessary to adjust the full throttle MAP. This was important for predicting maximum airspeed in level flight and climb performance at full throttle. The maximum MAP was calculated by

$$MAP_{max} = P_T - \left(P_{SL} - MAP_{maxSL}\right)$$

Effectively this equation says that the maximum MAP available is equal to the freestream total pressure (static pressure plus ram rise from airspeed) minus the losses in the intake manifold. The intake manifold losses were modeled as constant for all flight conditions. The intake manifold loss was determined by the standard sea level pressure (P_{SL} = 29.92 in Hg) minus the maximum MAP at sea level. Since the MAP at sea level on a standard day could not be measured directly, the value was adjusted until the predicted full throttle MAP satisfactorily matched the MAP recorded on flight test points at full throttle. These results are shown in Figure C10. The data points show a good agreement with the model predicted full throttle MAP (fairing).

When adjusting the maximum MAP at sea level in the engine model, it was also necessary to adjust the corresponding maximum BHP at sea level such that the maximum line of constant RPM did not change.

Rate of Climb Adjustment:

Two modifications were made to the *RPM* program to improve the match of climb predictions with flight test data. The first modification was to account for the expansion and contraction of pressure contours on non-standard days. On hot days, the pressure contours will expand, making 1000 feet of pressure altitude greater than 1000 feet of tapeline altitude. The opposite occurs on cold days. Pressure altitude is simply another unit for pressure, and a given change in pressure altitude at standard density will equate to a particular change in pressure. This change in pressure will also equate to the actual tapeline altitude change at the actual density. In equation form:

$$\Delta P = -\rho_s g \Delta H_p = -\rho_t g \Delta H_{tl}$$

Solving this equation for the ratio of pressure altitude change to tapeline altitude change gives

$$\frac{\Delta H_p}{\Delta H_{tl}} = \frac{\rho_t}{\rho_s} = \frac{\frac{P}{RT_t}}{\frac{P}{RT_s}} = \frac{T_s}{T_t}$$

where T_s is the standard temperature for the pressure altitude and T_t is the actual (or test) temperature.

Following this same line of reasoning, the effects of non-standard conditions can be seen on rate of climb. Assuming a hot day, if the aircraft has climbed 1000 feet of tapeline altitude, it may have only climbed through 930 feet of pressure altitude, since the vertical distance between pressure contours 1000 feet of pressure altitude apart is greater than 1000 feet of tapeline altitude. Thus, if the tapeline rate of climb was 1000 ft/min, the pressure altitude rate of climb would only be 930 ft/min. The rate of climb in terms of pressure altitude is what the pilot is interested in, since he is measuring altitude in terms of pressure altitude. Thus, the tapeline rate of climb calculated in *RPM* is adjusted to a pressure altitude rate of climb by the equation

$$ROC_{pressure} = ROC_{tl} * \frac{T_s}{T_t}$$

The second modification was to account for changes in drag on the aircraft caused by changes in the slipstream velocity. This is commonly referred to as "scrubbing." This scrubbing is usually a minor effect on the aircraft drag, but because of the separation over the rear window embedded in the slipstream, this effect was very noticeable on the Cessna 150. Since traditional aerodynamic theory normally considers this drag as part of the airframe drag, an equation to describe the effect was not immediately available. An empirical relationship was developed to model this effect. This relationship was

$$\Delta D_{slipstream} = C_{\Delta D} * \frac{\rho}{2}\left(v_i v_{i_{level}} - v_{i_{level}}^2\right) * S$$

where v_i is the propeller induced velocity at the current flight condition, and $v_{i_{level}}$ is the propeller induced velocity at the same conditions in level, unaccelerated flight. This relationship is patterned after the traditional expression for drag. Of interest is that because the propeller induced velocity is small compared to the freestream velocity, the coefficient ($C_{\Delta D}$) can be quite large compared to the aircraft drag coefficient. For instance, for the Cessna 150 tested, $C_{\Delta D} = 2.8$.

Figure C11 shows the effect of accounting for the slipstream effects. The circles show the actual data points (the 8,000 feet data from Figure A32). The upper line shows the *RPM* predicted rate of climb for the final model with all corrections except the slipstream drag correction (i.e. $C_{\Delta D} = 0$). Applying the slipstream drag correction moves the *RPM* predicted rate of climb down to the lower line, which shows excellent agreement with the data points.

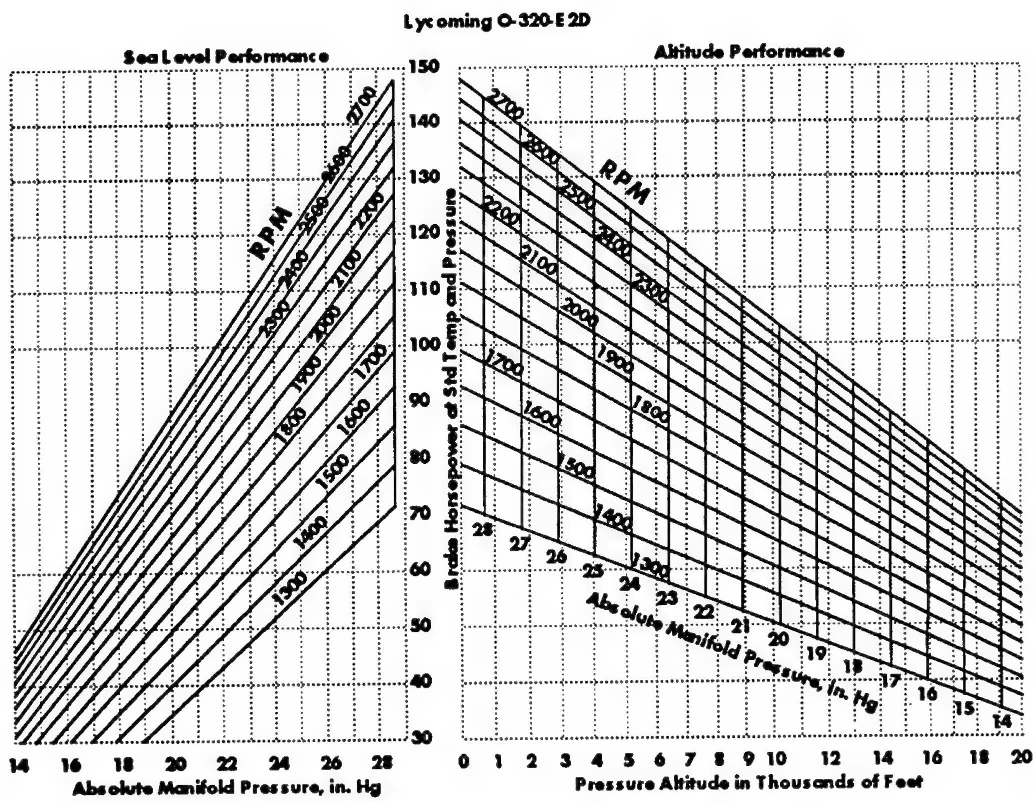


Figure C1 *RPM* Engine Model For Lycoming O-320-E2D

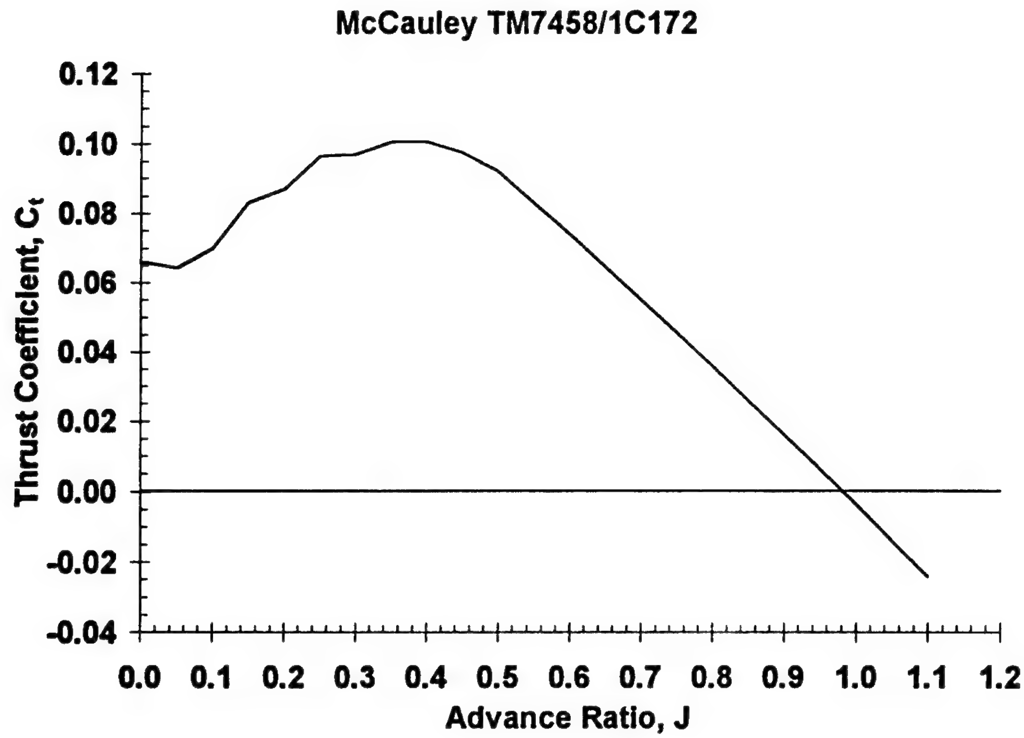


Figure C2 *RPM* Propeller Model For McCauley TM7458/1C172; Thrust Coefficient

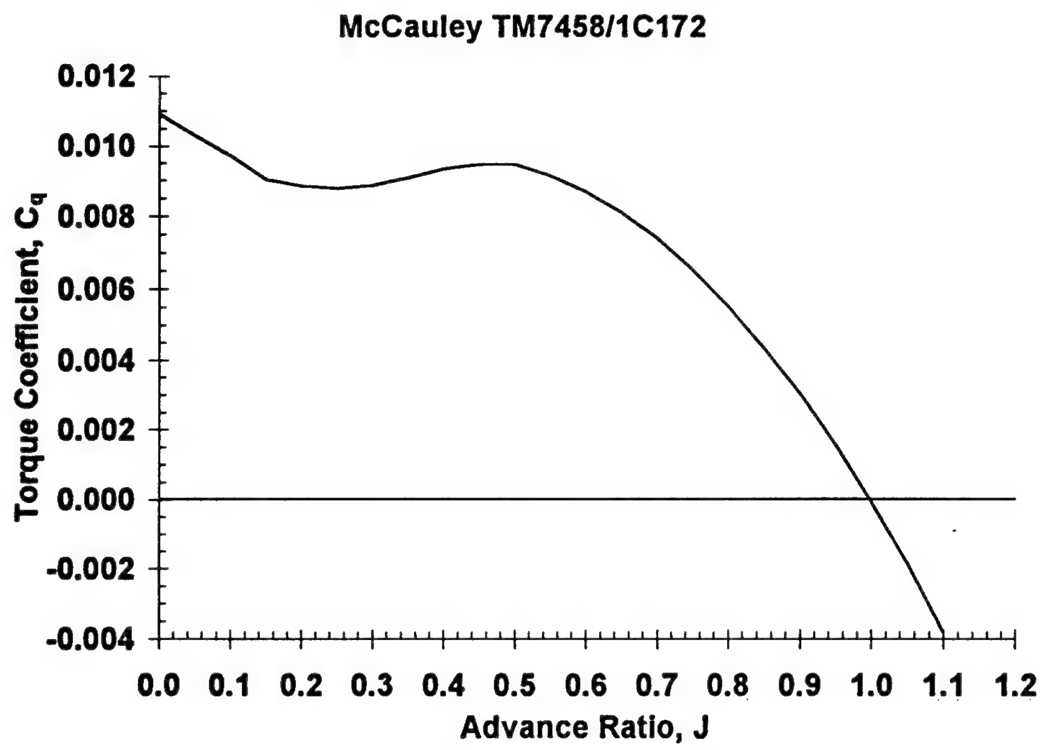


Figure C3 *RPM* Propeller Model For McCauley TM7458/1C172; Torque Coefficient

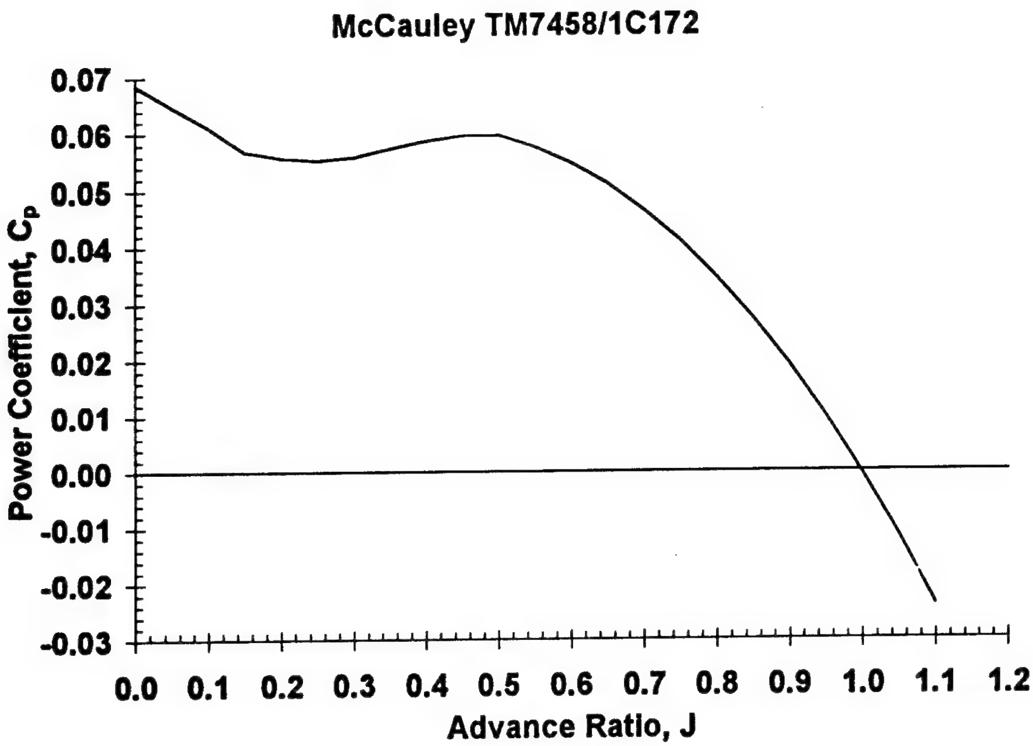


Figure C4 *RPM* Propeller Model For McCauley TM7458/1C172; Power Coefficient

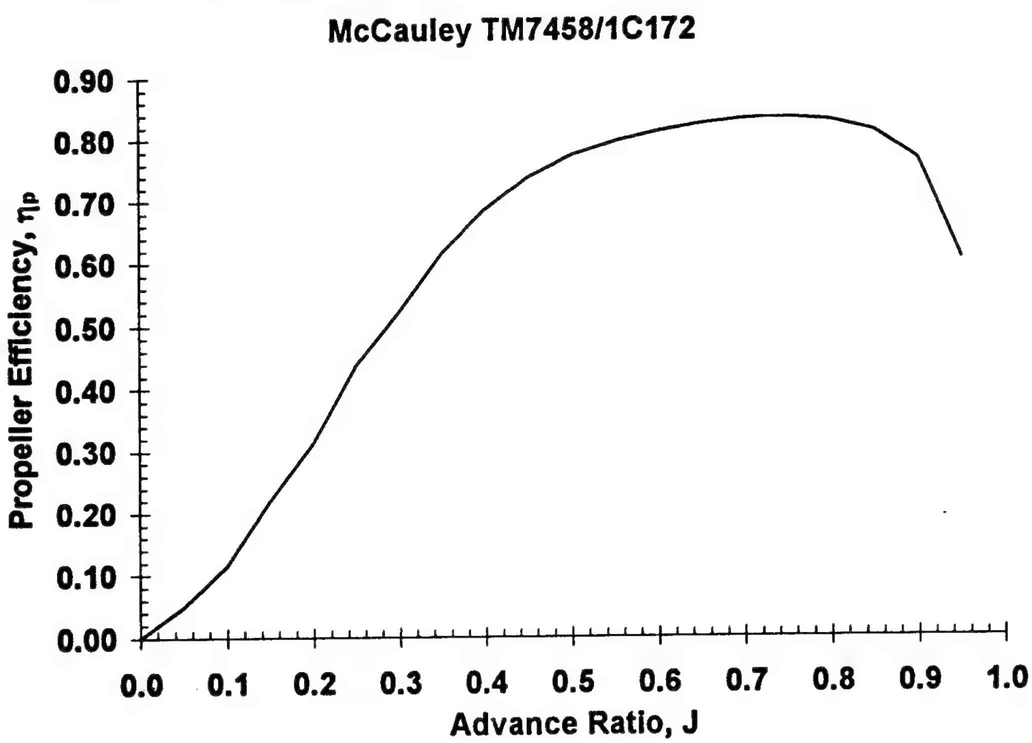


Figure C5 *RPM* Propeller Model For McCauley TM7458/1C172; Propeller Efficiency

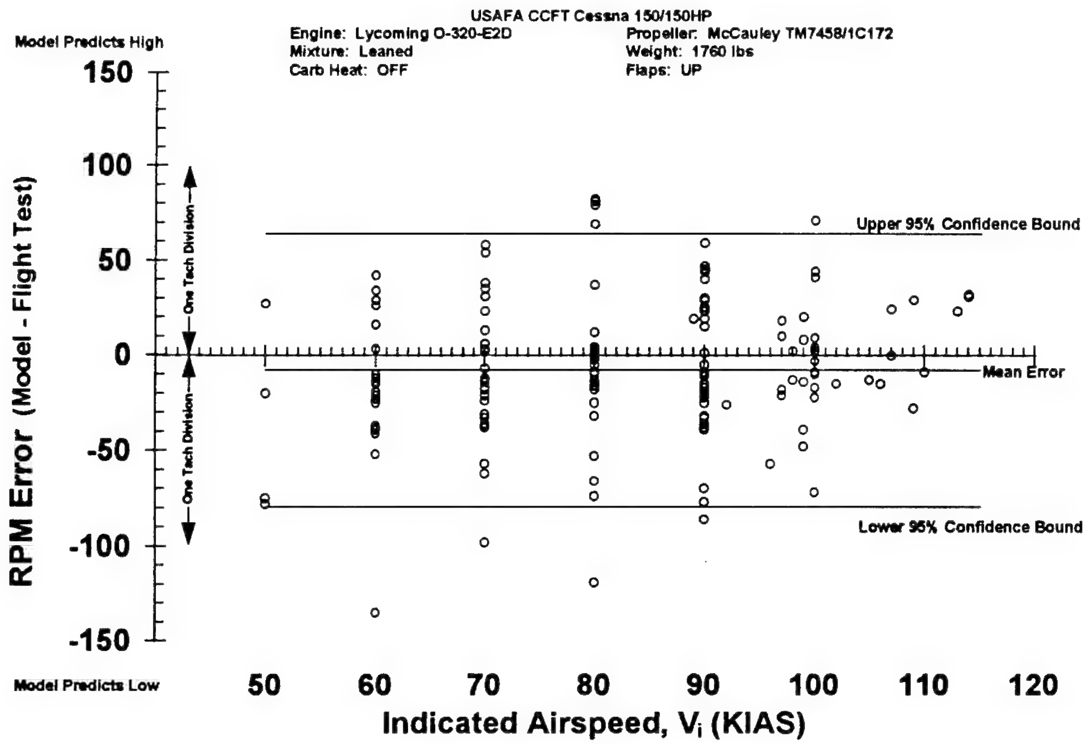


Figure C6 *RPM* Model RPM Matching

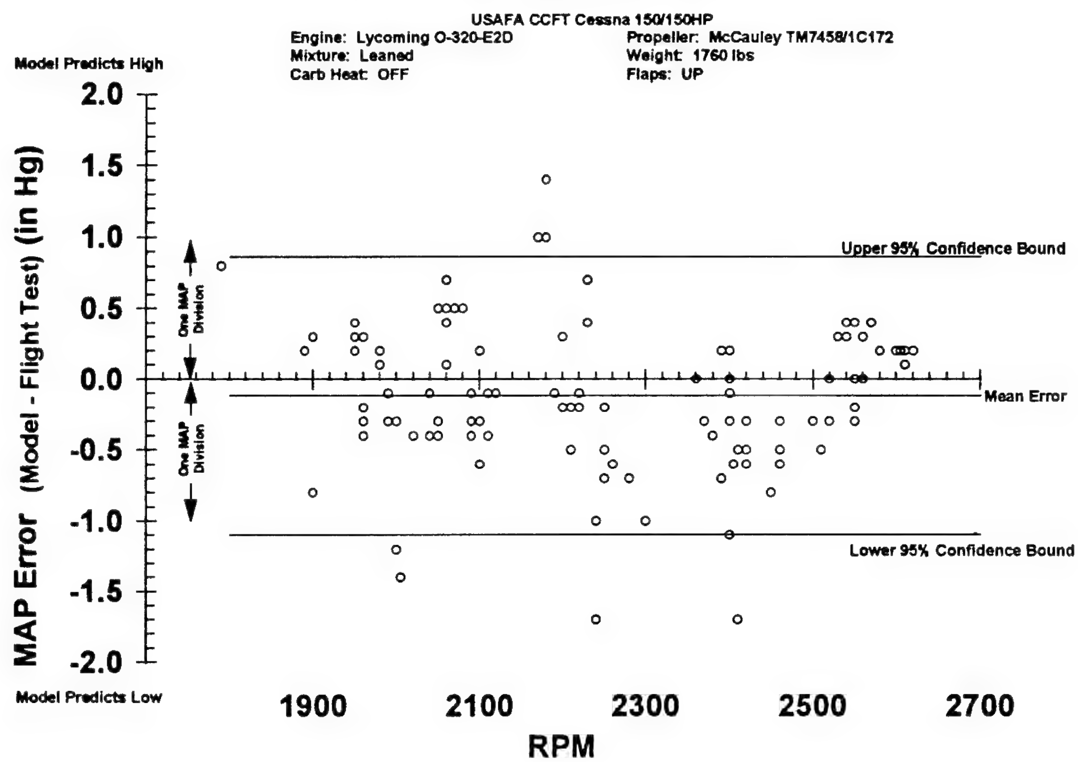


Figure C7 *RPM* Model Manifold Pressure Matching

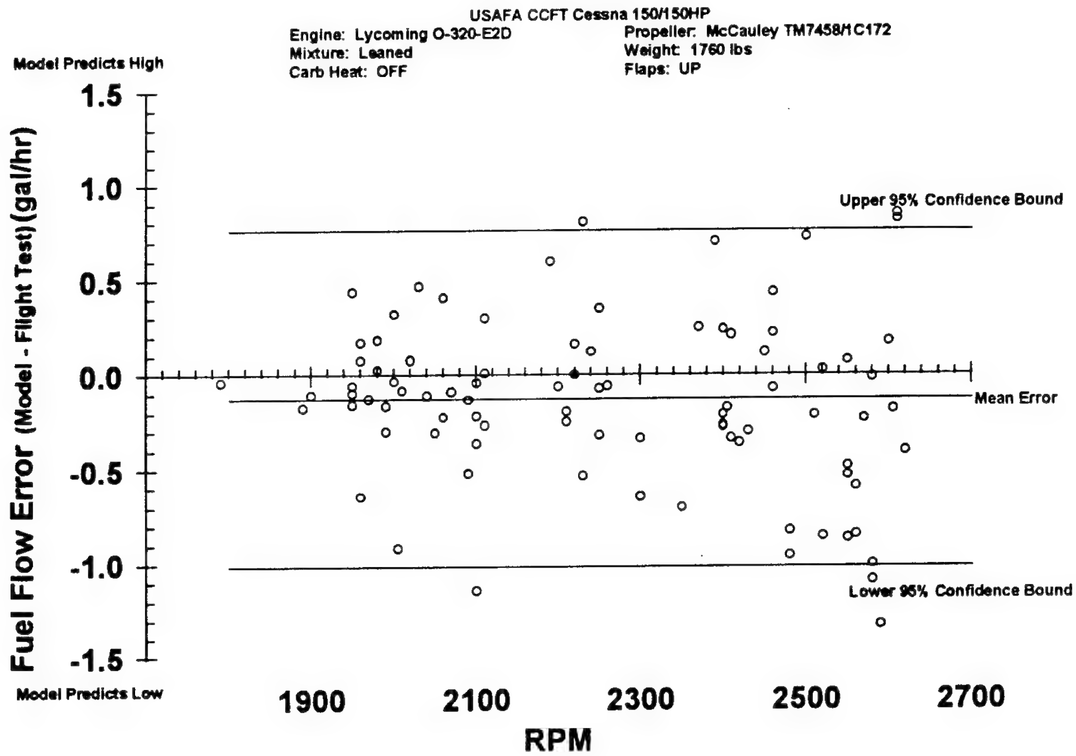


Figure C8 *RPM* Model Fuel Flow Matching (in gal/hr)

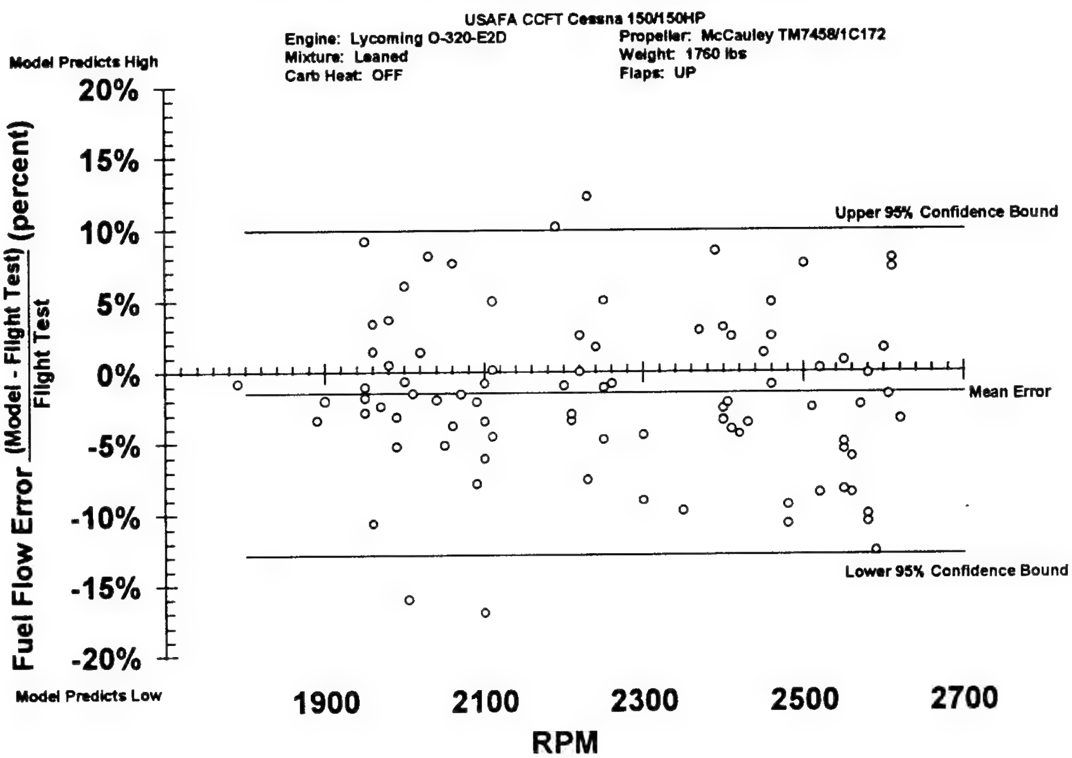


Figure C9 *RPM* Model Fuel Flow Matching (in percent)

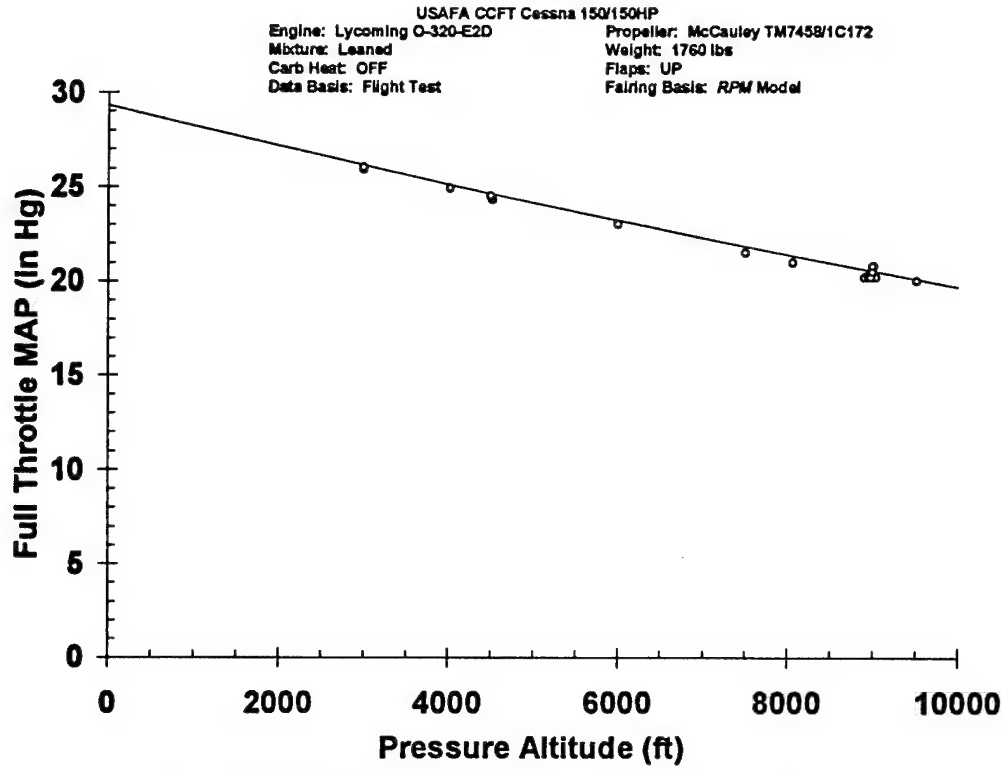


Figure C10 *RPM* Model Full Throttle Manifold Pressure Matching

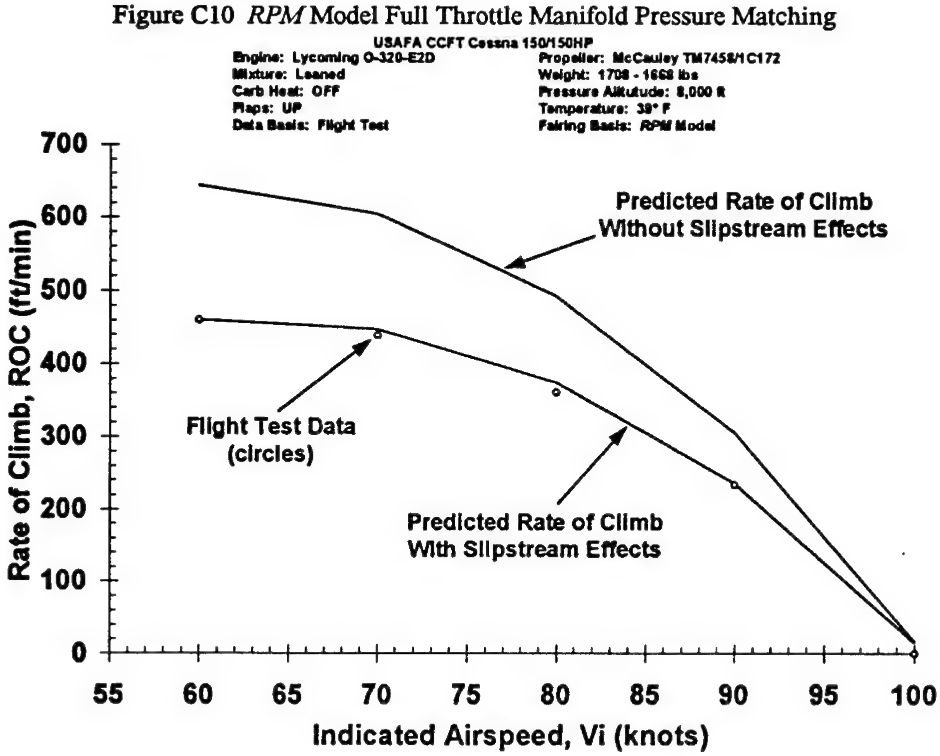


Figure C11 Slipstream Effects on Rate of Climb

AIRCRAFT MODEL FILE C150150.ACF

[General]
Aircraft Designation=USAFA CCFT Cessna 150/150HP
Engine Designation=LO320A.ENG
Prop Designation=C150150.PRP

[Weights]
Empty Weight=1267
Fuel Weight=138
Crew Weight=345
Baggage Weight=10
Max Gross Weight=1760
Maximum Fuel Weight=210

[Dimensions]
Wing Span=33.08
Wing Area=160
Number of Engines=1
CL Max=1.28036694423438
Wing Incidence=0.5
Thrust Incidence=0
Fuselage Deck Angle=0
CDo=0.042696
K2=0
K1=0.068861
Landing Gear Type 0=0
Landing Gear Type 1=-1
Retracts=0
Alpha Zero Lift=-2
Flaps List Index=4
Flapped Area=61
Fowler Flap Chord Ratio=1
Landing Gear CDo=0
Maximum Flap Deflection=40
Slipstream Drag Factor=2.8
Minimum Flap Deflection=0

[Simulation Options]
Airspeed Units 0=-1
Airspeed Units 1=0
Airspeed Units 2=0
Fuel Units 0=0
Fuel Units 1=-1
Fuel Units 2=0
Carb Heat Temp=150
VVI Lag Check=0
VVI Lag=9
Talking Otto=0

[Pitot Static Corrections]
Pitot Static Check=1

Position Correction Altitude=9000
Airspeed Rows=12
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Airspeed Instrument Error 1=0
Airspeed Position Error 1=0
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Calibrated Airspeed 1=0
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Calibrated Airspeed 6=134.266666666667
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ENGINE MODEL FILE LO320A.ENG

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Supercharger List Index=0
Auto Fit Coefficient 0=0
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Auto Fit Coefficient 1=1
Fit Coefficient 1=4.442958
Auto Fit Coefficient 2=1
Fit Coefficient 2=4.442958

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Low Normal RPM=2700
Low Normal PA=0
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Low Cruise RPM=2450
Low Cruise PA=7000
Low Gear Ratio=
Aux Military BHP=
Aux Military RPM=
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Aux Hi Gear Ratio=
Low Efficiency=
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Aux Efficiency=
Aux Efficiency Default=0
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[Engine Specs]
Engine Displacement=320
Bore=5.125
Stroke=3.875

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Cycle Type 1=0
Ram Effect=1
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Intercooler Exit Temp=
Intercooler Default=0
Check Aftercooler=0
Aftercooler Exit Temp=
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Turbo Control 0=0
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PROPELLER MODEL FILE C150150.PRP

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Max Blade Angle=
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APPENDIX D

FLIGHT TEST TECHNIQUE AND DATA REDUCTION DETAILED DESCRIPTION

CRUISE PERFORMANCE

Test Procedures:

Cruise data were collected using steady state trim shots at constant pressure altitude (PA) and airspeeds of 50, 60, 70, 80, 90, and 100 knots. Trim shots were also recorded at the airspeed for full throttle.

The aircraft was trimmed in level flight at the aim airspeed and pressure altitude. Heading was as desired by the pilot. The altimeter was set at 29.92 in Hg to indicate pressure altitude. Typically, a cruise test point was scheduled immediately after a Pitot-static test point (either GPS Speed Course or GPS Ground Speed) at the same conditions. This order allowed the pilot to fine tune the throttle based on the aircraft behaviour (slight gain or loss of airspeed or altitude) during the Pitot-static test point. Since the Pitot-static test points were less sensitive to altitude deviations, more complete use of test time was possible while getting a good trim shot for the cruise test point. During the test point, airspeed was held constant, allowing the alititude to vary slightly if necessary. Any altitude deviations were recorded as part of the test data.

Once the pilot called "On Conditions," the flight test engineer started pushing the button on the fuel totalizer to display fuel used, and waited until the tenths digit (the least significant figure) changed. When the tenths digit changed, the time was recorded. At this time the test point was started. The flight test engineer recorded the starting fuel used, indicated altitude (h_i), indicated airspeed (V_i), outside air temperature (OAT), manifold pressure (MAP), engine RPM, and pilot comments. The flight test engineer would then repeatedly push the button on the fuel totalizer until the indicated fuel used was 0.5 gallon greater than the starting fuel used. On the first indication of the final fuel used, the time was recorded, and the test point was complete.

Fuel used was measured by a Hoskins FT101A Fuel Totalizer. The manufacturer's literature for this instrument claims an accuracy within ±2 percent. After the first two flights of the program, when it became apparent that the fuel totalizer was indicating incorrectly, the instrument was sent back to the manufacturer to be recalibrated. No separate verification of the calibration was accomplished by the test team. Fuel used was reported to the nearest tenth of a gallon. This indicator normally displayed fuel flow, which varied too much to be usable for this test. This variation arose primarily from the actual variation in fuel flow as the carburetor float opened and closed the fuel inlet valve to the carburetor bowl. Fuel used could be read by pressing a button on the indicator. After displaying the fuel used for a few seconds, the display would revert to fuel flow.

To improve the accuracy of the fuel used measurement, the flight test engineer pressed the button on the indicator each time the display reverted to fuel flow. This resulted in a reasonably constant display of fuel used.

Figure D1 shows why a value of 0.5 gallons was chosen. This figure assumed zero error in the fuel used indicator and a nominal cruise fuel flow of 8 gallons per hour. Time was read from a digital wristwatch displaying hours, minutes, and seconds. This method introduced a random error of ±0.5 seconds. All time readings would be late, as it would be impossible to see a display change before it changes. If the time readings at the beginning and the end of the run were both 1 second late, for instance, then the time recorded for the run would have no error. If the ending time had more error than the starting time, the time recorded for the run would be too long. If the starting time had more error than the ending time, the time recorded for the run would be too short. Considering time to notice the change on the fuel used display and look at the watch, a time error of no more than 2 seconds was considered reasonable. For this time error, burning 0.5 gallons would result in a measurement error of 0.88 percent. This error is less than the ±2 percent error claimed by the manufacturer for the fuel totalizer, and therefore is not worth trying to reduce further. Burning 1.0 gallons would only reduce the error to 0.44 percent. This would result in a small reduction in error but a large increase in flight time, lengthening a typical test point from 5 minutes to 10 minutes. Balancing error reduction against efficient use of flight time, a fuel burn of 0.5 gallons was chosen.

The amount of fuel in the tanks was measured before and after each flight in an attempt to verify the accuracy of the fuel totalizer. The amount of fuel was measured using a dipstick. The mean error comparing the measured fuel amount to the fuel burned shown on the fuel totalizer was 1.2 gallons per flight. However, the standard deviation was so large (1.6 gallons per

flight) as to make the results inconclusive. The large standard deviation was thought to be caused primarily by the large errors inherent in measuring the fuel in the tanks with a dipstick. The dipstick had a very low resolution (1 gallon), and the amount read was dependant on the attitude of the airplane. Since the aircraft was not always parked in the same spot when the dipstick was read, additional errors were introduced into this measurement. The one conclusion that can be safely drawn is that the data did not statistically show that the fuel totalizer was inaccurate, therefore the fuel totalizer was assumed accurate.

Data Reduction Methods:

Example Data:

h_i = 5990 feet

V_i = 90 KIAS

T_i = 31° F

MAP = 18.6 in Hg

RPM = 2230

Start Time = 9:35:27

End Time = 9:40:00

Start Fuel Used = 6.0 gal

End Fuel Used = 6.5 gal

Takeoff Weight = 1780 lbs

Propeller Diameter = 6.1667 ft

Standard Weight = 1760 lbs

Wing Area = 160 ft^2

Temperature Recovery Factory (K) = 0.8

1. Find the airspeed position correction from the flight test derived position correction chart (Figure A27).

At 90 KIAS, ΔV_{pc} = -2 knots

2. Find the calibrated airspeed.

$$V_{pc} = V_i + \Delta V_{pc}$$

$$V_{pc} = 88 \text{ KCAS}$$

3. Find the fuel flow.

$$\dot{w}_f = \frac{\text{Start Fuel} - \text{End Fuel}}{\text{End Time} - \text{Start Time}} * \frac{3600 \text{ seconds}}{\text{hour}}$$

$$\dot{w}_f = 6.593 \text{ gal/hr}$$

4. Find gross weight.

$$\text{Fuel Used} = \frac{\text{End Fuel Used} - \text{Start Fuel Used}}{2}$$

$$\text{Fuel Used} = 6.25 \text{ gal}$$

$$W_t = \text{Takeoff Weight} - \text{Fuel Used} * 6\frac{\text{lb}}{\text{gal}}$$

$$W_t = 1742.5 \text{ lbs}$$

5. Find pressure ratio (P/P_{sl}).

$$\delta_t = (1 - 6.87559\text{x}10^{-6}\, h_i)^{5.2559}$$

$$\delta_t = 0.801679$$

6. Find Mach Number.

$$M = \sqrt{5\left[\left(\frac{1}{\delta_t}\left\{\left[1+0.2\left(\frac{V_{pc}}{a_{sl}}\right)^2\right]^{3.5} - 1\right\}+1\right)^{2/7} - 1\right]}$$

$$M = 0.148501$$

7. Find ambient temperature.

$$T_a = \frac{T_i + 460}{1+0.2KM^2}$$

$$T_a = 489° \text{ R}$$

8. Find temperature ratio (T/T_{sl}).

$$\theta_t = \frac{T_a}{T_{sl}}$$

$\theta_t = 0.942724$

9. Find density ratio (ρ/ρ_{sl}).

$$\sigma_t = \frac{\delta_t}{\theta_t}$$

$\sigma_t = 0.850386$

10. Find altitude position correction.

$$h_{pc} = h_i + \frac{V_c^2 - V_i^2}{2\sigma_t g} * \left(\frac{6080 \text{ ft / mi}}{3600 \text{ sec/ hr}}\right)^2$$

$h_{pc} = 5971$ feet

11. Find true airspeed.

$$V = Ma_{sl}\sqrt{\theta_t}$$

$V = 161$ ft/sec

12. Find equivalent airspeed.

$$V_e = V_t\sqrt{\sigma_t} * \frac{3600 \text{ sec/ hr}}{6080 \text{ ft / nm}}$$

$V_e = 87.9$ KEAS

13. Standardize airspeed to sea level and standard weight.

$$V_{iw} = V_e\sqrt{\frac{W_s}{W_t}}$$

$V_{iw} = 88.3$ knots

14. Find test brake horsepower from engine chart (Figure C1).

$BHP_t = 74.3$ hp

15. Find propeller advance ratio.

$$J = \frac{V}{RPM * D} * \frac{60 \text{ sec}}{\text{min}}$$

$J = 0.702$

16. Find propeller efficiency from chart (Figure C5).

$\eta_p = 0.832$

17. Find propeller power coefficient from chart (Figure C4).

$C_p = 0.0461$

18. Find test brake horsepower from propeller power coefficient.

$$BHP_t = C_p \rho_{sl} \sigma_t (RPM)^3 D^5 * \left(\frac{\text{min}}{60 \text{ sec}}\right)^3 * \left(\frac{550\frac{\text{ft lbs}}{\text{sec}}}{\text{hp}}\right)$$

$BHP_t = 77.6$ hp

19. Standardize brake horsepower to sea level and standard weight. Use the BHP_t from the engine chart if available (Step 14). Otherwise use BHP_t obtained from the propeller power coefficient.

$$BHP_{iw} = BHP_t \sigma_t^{1/2}\left(\frac{W_s}{W_t}\right)^{3/2}$$

$BHP_{iw} = 69.6$ hp

20. Find Lift Coefficient.

$$C_L = \frac{2W_t}{\rho_{sl} V_e^2 S} * \left(\frac{3600 \text{ sec/ hr}}{6080 \text{ ft / nm}}\right)^2$$

$C_L = 0.424$

21. Find Drag Coefficient.

$$C_D = \frac{\eta_p \, BHP_t}{V} \frac{2}{\rho_{sl}\sigma_t V^2 S} * \left(\frac{550 \frac{\text{ft lbs}}{\text{sec}}}{\text{hp}} \right)$$

$C_D = 0.0514$

22. Find Specific Air Range.

$$SAR = \frac{V}{\dot{w}_f} \frac{W_t}{W_s} * \frac{3600 \text{ sec/hr}}{6080 \text{ ft/nm}}$$

SAR = 14.3 nm/gal

23. Find Specific Endurance.

$$SE = \frac{1}{\dot{w}_f} \left(\frac{W_t}{W_s} \right)^{3/2}$$

SE = 0.149 hr/gal

24. Find Brake Specific Fuel Consumption

$$BSFC = \frac{\dot{w}_f}{BHP_t}$$

BSFC = 0.532 lb/hp/hr

Data Presentation:

True Airspeed and RPM at Non-Standard Conditions.

Figure A13 and Figure A14 are both plotted with an entry on the left side by density altitude. The implication of the plotting method is that the true airspeed and engine RPM will be the same for any two flight conditions at the same density altitude, the same percent power setting, and the same weight. To see this is true, consider two flight conditions at the same density altitude, the same power setting (in percent power) and the same weight:

Case 1: Standard pressure, standard density

Case 2: Non-standard pressure, non-standard density

So far we know

$W_1 = W_2$

$BHP_1 = BHP_2$

For cruise in level, unaccelerated flight, lift equals weight, so

$L_1 = L_2$

$$C_{L_1} \frac{\rho_1 V_1^2}{2} S = C_{L_2} \frac{\rho_2 V_2^2}{2} S$$

Since $\rho_1 = \rho_2$ (same density altitude), S = S, and 2 = 2, we have two options to satisfy this equality:

1. $C_{L_1} = C_{L_2}$ and $V_1 = V_2$

2. $\frac{C_{L1}}{C_{L2}} = \frac{V_2}{V_1}$

Since $BHP_1 = BHP_2$ then

$$\frac{D_1 V_1}{\eta_{p1}} = \frac{D_2 V_2}{\eta_{p2}}$$

Converting drag to coefficient form

$$C_{D1} \frac{\rho_1 V_1^3}{2\eta_{p1}} S = C_{D2} \frac{\rho_2 V_2^3}{2\eta_{p2}} S$$

Again, $\rho_1 = \rho_2$ (same density altitude), S = S, and 2 = 2, leaving

$$\frac{C_{D1}}{C_{D2}} = \frac{\eta_{p1} V_2^3}{\eta_{p2} V_1^3}$$

Expressing the drag coefficient as the drag polar,

$$\frac{C_{D_o} + KC_{L1}^2}{C_{D_o} + KC_{L2}^2} = \frac{\eta_{p1} V_2^3}{\eta_{p2} V_1^3}$$

Substituting for the lift coefficient,

$$C_L = \frac{2W}{\rho V^2 S}$$

$$\frac{C_{D_o} + \dfrac{4KW^2}{\rho^2 S^2 V_1^4}}{C_{D_o} + \dfrac{4KW^2}{\rho^2 S^2 V_2^4}} = \frac{\eta_{p_1} V_2^3}{\eta_{p_2} V_1^3}$$

Ouch! Let's group constants as

$$c_1 = C_{D_o}$$

$$c_2 = \frac{4KW^2}{\rho^2 S^2}$$

$$\frac{c_1 + c_2 V_1^{-4}}{c_1 + c_2 V_2^{-4}} = \frac{\eta_{p_1} V_2^3}{\eta_{p_2} V_1^3}$$

Rearranging,

$$\eta_{p_2} V_1^3 \left(c_1 + c_2 V_1^{-4}\right) = \eta_{p_1} V_2^3 \left(c_1 + c_2 V_2^{-4}\right)$$

$$c_1 \eta_{p_2} V_1^3 + c_2 \eta_{p_2} V_1^{-1} = c_1 \eta_{p_1} V_2^3 + c_2 \eta_{p_1} V_2^{-1}$$

$$V_1^3 + \frac{c_2}{c_1}\frac{1}{V_1} = \frac{\eta_{p_1}}{\eta_{p_2}} V_2^3 + \frac{c_2}{c_2}\frac{\eta_{p_1}}{\eta_{p_2}}\frac{1}{V_2}$$

$$V_1^3 - \frac{\eta_{p_1}}{\eta_{p_2}} V_2^3 = \frac{c_2}{c_1}\left(\frac{\eta_{p_1}}{\eta_{p_2}}\frac{1}{V_2} - \frac{1}{V_1}\right)$$

For a fixed pitch propeller, a given RPM will result in a unique airspeed in level unaccelerated flight. Given the power coefficient

$$C_p = \frac{BHP}{\rho (RPM)^3 D^5}$$

If we assume temporarily that the RPM for both cases is the same, and we know that the BHP, density, and prop diameter are the same for both cases, then the power coefficient will be the same for both cases. The power coefficient is a unique function of advance ratio, so the advance ratio must be the same for both cases. The propeller efficiency is also a unique function of advance ratio, so the propeller efficiency must be the same for both cases. Therefore,

$$V_1^3 - V_2^3 = \frac{c_2}{c_1}\left(\frac{1}{V_2} - \frac{1}{V_1}\right)$$

This equation will be satisfied if $V_1 = V_2$. If $V_1 = V_2$, then $RPM_1 = RPM_2$, since a given RPM will result in a unique airspeed in level unaccelerated flight. Thus all equations and conditions are satisfied. Because airspeed is uniquely related to RPM, and this is a solution to the equation, then it is the only solution. Therefore, true airspeed and RPM will be the same for any condition at a given weight, power setting, and density altitude.

Fuel Flow at Non-Standard Conditions.

Figure A15 shows a correction to fuel flow for non-standard temperatures. This correction has the functional relationship of

$$\dot{w}_{f_t} = \dot{w}_{f_s}\left(\frac{T_s}{T_t}\right)^{1/2}$$

where T_s is the standard temperature at altitude and T_t is the actual temperature at altitude. Strictly speaking, the relationship shown is

$$\dot{w}_{f_t} = \dot{w}_{f_s}\left(\frac{T_{sl}}{T_{sl} + \Delta T}\right)^{1/2}$$

for ease of graphing. While the ratio will change as the standard temperature changes with altitude, the difference is very slight. For instance, at 10,000 feet pressure altitude and a temperature 40° F above standard, the change in fuel flow is a factor of 0.961 using the standard temperature at 10,000 feet. Using the sea level standard temperature and an actual temperature 40° F above standard, the change in fuel flow is a factor of 0.964, or an error of 0.3 percent.

The basis for this relationship can be seen by looking at the change in the air mass flow rate at non-standard conditions. Recall that the fuel flow is related to the air mass flow rate by the mixture ratio. Consider

two flight conditions at the same pressure altitude, the same power setting (in percent power) and the same weight:

Case 1: Standard pressure, standard density

Case 2: Standard pressure, non-standard density (i.e. non-standard temperature)

In case 2, increasing the temperature (decreasing the density) will reduce the load on the propeller, allowing it to turn faster at the same brake horsepower input. However, the increased temperature reduces that brake horsepower output of the engine, so the MAP must be increased to maintain the same brake horsepower. However, the MAP and RPM increases are not as great as the increase in temperature, such that considering the air mass flow equation,

$$\dot{m}_{air} = \frac{MAP}{R * T} * \frac{RPM}{2} * \text{Displacement} * \eta_{vol}$$

the overall result is that less airflow, and thus less fuel flow is required at higher temperatures for the same brake horsepower. This is also reasonable considering that since the engine is producing more RPM, less torque is required for the same power. Since less torque is required, less fuel-air mixture is required in the cylinders, and hence less airflow. The relationship stated for correcting fuel flow for non-standard conditions is the relationship that empirically best matched the results from the *RPM* model.

Range and Endurance at Non-Standard Conditions.

Range is a function of both true airspeed and fuel flow. The simplest form of the range equation would be

$$R = SAR * \Delta t = \frac{V}{\dot{w}_f} \Delta t$$

The only variables affected by non-standard conditions are the true airspeed and the fuel flow. Thus, the range can be adjusted for non-standard conditions by using the same adjustments as used for true airspeed and fuel flow. The true airspeed is accounted for by entering the range chart with density altitude. The fuel flow correction is the same as discussed for cruise, except that it is inverted since fuel flow is in the denominator (hence the opposite slope in the guide lines). This method agrees well with the *RPM* model predictions for non-standard conditions.

Endurance is a function only of fuel flow. The simplest form of the endurance equation would be

$$R = SE * \Delta t = \frac{1}{\dot{w}_f} \Delta t$$

The only variable affected by non-standard conditions is the fuel flow. Thus, the endurance can be adjusted for non-standard conditions by using the same adjustment as used for fuel flow. The fuel flow correction is the same as discussed for cruise, except that it is inverted since fuel flow is in the denominator (hence the opposite slope in the guide lines). This method agrees well with the *RPM* model predictions for non-standard conditions.

PITOT-STATIC CALIBRATION

Test Procedures:

GPS Speed Course Method.

This Pitot-static calibration method was an adaptation of the traditional ground speed course method (Reference 3). Instead of using landmarks to determine distance, Global Positioning System (GPS) distance-to-go readings were used. These distance-to-go readings were based on a waypoint at least 30 nm away, as shown in Figure D2. At this distance the arcs of constant distance to the waypoint will appear as essentially parallel lines to the aircraft. The waypoint was chosen such that the heading directly toward or away from the waypoint would be approximately perpendicular to the wind. A commercially available Garmin GPS 55 was used for this test.

Winds should be calm, but no greater than a 10 knot crosswind component. Stronger winds will introduce more drift, and will likely include more turbulence.

The aircraft was flown on a heading directly toward and away from the waypoint with no wind drift correction. The Pitot tube senses airspeed in the direction of the aircraft heading, not the aircraft track. Therefore, the distance measured must be in the direction of the aircraft heading. This distance is

measured by maintaining the initial heading to the station. Wind drift will add a minimal error because the arcs are not parallel. Figure D3 shows the error in measuring distance introduced by a worst case scenario of low airspeed (50 KTAS), and a strong crosswind (10 knots). The drift angle for this scenario is 11.3 degrees, and over a 4 nm leg the aircraft will drift 0.799 nm. On a 30 nm arc, this will result in a distance error of an additional 0.0106 nm in the heading direction, which is 0.26 percent of 4 nm. This is an acceptable error in distance measurement, and will be smaller at higher airspeeds and lower crosswinds.

Errors introduced by headwinds or tailwinds were removed by flying the course twice on opposite headings, both to and from the waypoint. The measured groundspeed (distance divided by time) for both legs were averaged to find the true airspeed. This method assumed that the wind velocity remained constant for both runs, and no wind gradients existed along the speed course. A drawback of this method was that this assumption could not be tested for validity during flight.

All Pitot-static errors were assumed to be in the measurement of static pressure. Total pressure (Pitot pressure) was assumed to have no errors. Airspeed and altitude instrument errors were assumed to be negligible.

The aircraft was trimmed in level flight at the aim airspeed and pressure altitude, on a heading either directly toward or away from the waypoint. This heading was taken as the course (or its reciprocal) to the waypoint shown by the GPS. The altimeter was set at 29.92 in Hg to indicate pressure altitude. During the test point, airspeed was held constant, allowing the alititude to vary slightly if necessary. Any altitude deviations were recorded as part of the test data.

Once the pilot called "On Conditions," the flight test engineer watched the distance-to-go on the GPS. When the tenths digit changed, the starting time and distance-to-go were recorded. At this time the test point was started. The flight test engineer recorded the starting fuel used, h_i, V_i, OAT, MAP, engine RPM, and pilot comments. The ending time was recorded when the distance-to-go was 4 nm less (or greater) than the starting distance-to-go. The ending fuel used was recorded, and the test point was complete.

Figure D4 shows why a leg distance of 4.0 nm was chosen. Since errors in timing would be increased with increasing airspeed, this figure shows a worst case scenario at 100 KTAS. Time was read from a digital wristwatch displaying hours, minutes, and seconds. This method introduced a random error of ±0.5 seconds. All time readings would be late, as it would be impossible to see a display change before it changes. If the time readings at the beginning and the end of the run were both 1 second late, for instance, then the time recorded for the run would have no error. If the ending time had more error than the starting time, the time recorded for the run would be too long. If the starting time had more error than the ending time, the time recorded for the run would be too short. Figure D4 shows the error in measured ground speed for recorded times 1, 2, and 5 seconds too long. Considering time to notice the change on the GPS display and look at the watch, a time error of no more than 2 seconds was considered reasonable. For this time error, flying 1 nm resulted in an error of 5.2 percent. Flying 4 nm reduced this error to 1.3 percent. Increasing the leg length more would only reduce the error slightly while greatly increasing the flight time required. Thus, 4 nm was chosen as the appropriate leg length.

Data Reduction Methods

Example Data:

Temperature Recovery Factory (K) = 0.8

C_p (specific heat) = 6009 ft^2/sec^2/°R

Standard Altitude = Sea Level

Ratio of Specific Heats (γ) = 1.4

First leg:

V_i = 90 KIAS

h_i = 9000 ft

T_i = 34° F

Start Time$_1$ = 7:31:08

End Time$_1$ = 7:34:07

Distance$_1$ = 5 nm

Second leg:

$V_i = 90$ KIAS

$h_i = 9040$ ft

$T_i = 34°$ F

Start $Time_2 = 7{:}35{:}39$

End $Time_2 = 7{:}38{:}02$

$Distance_2 = 4$ nm

1. Find true airspeed from average ground speed.

$$V = \frac{1}{2}\left(\frac{Distance_1}{End\ Time_1 - Start\ Time_1} + \frac{Distance_2}{End\ Time_2 - Start\ Time_2}\right) * 3600\frac{sec}{hr}$$

$V = 100.6$ KTAS

2. Find ambient temperature.

$$T_a = T_i - \frac{KV^2}{2C_p} * \left(\frac{6080\ ft/nm}{3600\ sec/hr}\right)^2 + 460$$

$T_a = 492.1°$ R

3. Find temperature ratio (T/T_{sl}).

$$\theta_t = \frac{T_a}{T_{sl}}$$

$\theta_t = 0.9481$

4. Find Mach Number based on measured true airspeed.

$$M = \frac{V}{a_{sl}\sqrt{\theta_t}}$$

$M = 0.1563$

5. Find instrument corrected altitude

$h_{ic} = h_i + \Delta h_{ic}$

$h_{ic} = 9020$ feet (for this test, assume $\Delta h_{ic} = 0$)

6. Find instrument corrected airspeed

$V_{ic} = V_i + \Delta V_{ic}$

$V_{ic} = 90$ KIAS (for this test, assume $\Delta V_{ic} = 0$)

7. Find pressure ratio (P/P_{sl}).

$\delta_{ic} = (1 - 6.87559 \times 10^{-6}\, h_{ic})^{5.2559}$

$\delta_{ic} = 0.7143$

8. Find Mach number based on indicated airspeed and pressure altitude.

$$M = \sqrt{5\left[\left(\frac{1}{\delta_{ic}}\left\{\left[1 + 0.2\left(\frac{V_{ic}}{a_{sl}}\right)^2\right]^{3.5} - 1\right\} + 1\right)^{2/7} - 1\right]}$$

$M_{ic} = 0.1609$

9. Find the Mach position correction.

$\Delta M_{pc} = M - M_{ic}$

$\Delta M_{pc} = -0.00461$

10. Find the temperature ratio at standard altitude to convert flight test corrections to standard altitude.

$\theta_{s_{std}} = (1 - 6.87559 \times 10^{-6}\, h_{std})$

$\theta_{s_{std}} = 1$

11. Find altitude position correction.

$$\Delta H_{pc} = \frac{\theta_{s_{std}}}{3.61382 \times 10^{-5}} \frac{\gamma M_{ic} \Delta M_{pc}}{1 + 0.2M_{ic}^2}$$

$\Delta H_{pc} = -28.6$ feet

12. Find airspeed position correction.

$$\Delta V_{pc} = \frac{a_{sl}^2 \delta_{ic}}{\left[1+0.2\left(\frac{V_{ic}}{a_{sl}}\right)^2\right]^{2.5} V_{ic}} \frac{M_{ic}\Delta M_{pc}}{1+0.2M_{ic}^2}$$

ΔV_{pc} = -2.5 knots

GPS Ground Speed Method:

The GPS ground speed method was developed at the USAF Test Pilot School (USAF TPS), and became known to the test team during the flight test phase of this project (Reference 4). Additional Pitot-static testing was completed to compare the relative position errors of different CCFT aircraft, and at the request of USAF TPS for further development of this method.

In this method, the aircraft true airspeed was estimated based on indicated airspeed, estimated position correction, pressure altitude, and outside air temperature using a flight computer, such as an E-6B. Starting on a heading with an expected headwind or tailwind, based on forecasted winds aloft, a slow turn was initiated. As shown in Figure D5, the turn was continued until the GPS ground speed was equal to the estimated true airspeed. The aircraft was then stabilized on heading and the ground speed and ground track were recorded. Turning 180 degrees to the reciprocal heading, the ground speed and ground track were again recorded and compared to the previous values. If the aircraft was flown perpendicular to the wind, the ground speeds would be equal and the absolute difference between the ground tracks and headings flown would be equal. If these data were different, the actual direction of the wind could be determined from the data and the heading refined. To prevent infinite iterations, a difference of 5 knots in ground speed between the two directions was determined to be acceptable.

The aircraft was flown at the aim airspeed and altitude on the crosswind heading. The primary data collected were V_i, heading, GPS ground speed, and GPS track angle. Additionally, h_i, OAT, MAP, RPM, fuel used, and pilot comments were collected. The primary data were recorded multiple times for approximately one minute to detect any variations from outside effects such as wind gradients. The same data were collected for the same flight conditions on the reciprocal heading. The true airspeed was determined by multiplying the GPS ground speed by the cosine of the angle difference between the heading angle and the GPS track angle (i.e. the drift angle).

Flying each test condition on reciprocal headings perpendicular to the wind minimized the headwind and tailwind components. As shown in Figure D6, the average of the true airspeed calculated for each direction will give the actual true airspeed, even if the headings flown are not exactly perpendicular to the wind. The combined length of the two calculated true airspeed vectors is the same as twice the length of the actual true airspeed vector. Therefore dividing the combined length of the two calculated true airspeed vectors in half (i.e. averaging them) will give the actual true airspeed. For example, assume the two runs are flown on headings of 090° (Mag Heading 1) and 270° (Mag Heading 2) at 50 KTAS (True Airspeed). The wind direction is 040° at 10 knots. For run 1, the drift angle would be 9.97°, and the calculated true airspeed would be 43.58 KTAS. For run 2, the drift angle would be 7.73°, and the calculated true airspeed would be 56.42 KTAS. Averaging 43.58 KTAS and 56.42 KTAS gives the correct true airspeed, 50 KTAS.

A strength of the GPS Ground Speed method is that certain errors caused by winds and wind gradients can be identified in flight. The data tolerances were ±100 feet altitude, ±1 knot indicated airspeed, and ±2 degrees heading. If the GPS groundspeed varied more than 5 knots during a run or the track varied more than 5 degrees the data were discarded. Either of these conditions would indicate wind gradients which would corrupt the data. Additionally, the data were discarded if the ground speed corrected for drift angle (calculated true airspeed) was more than 5 knots different between test points at the same conditions in opposite directions. This error would indicate a change in the wind direction and a need to re-determine the crosswind heading.

Data Reduction Methods

Example Data:

Aim Airspeed = 50 KIAS

Temperature Recovery Factory (K) = 0.8

C_p (specific heat) = 6009 $ft^2/sec^2/°R$

Standard Altitude = Sea Level

Ratio of Specific Heats (γ) = 1.4

First leg:

h_i = 9020 ft

T_i = 61° F

Second leg:

h_i = 8980 ft

T_i = 61° F

Additional data for these runs are shown in Table D1.

1. Find drift angle.

Drift Angle = GPS Mag Track - Mag Heading

See Table D1 for results.

2. Calculate true airspeed as the component of ground speed in the heading direction.

V = GPS Ground Speed * cos(Drift Angle)

See Table D1 for results.

Table D1

GPS GROUND SPEED METHOD EXAMPLE DATA

Magnetic Heading (deg)	Indicated Air Speed (knots)	GPS Track (deg)	GPS Ground Speed (knots)	Drift Angle (deg)	True Air Speed (knots)	Adjusted True Air Speed (knots)
First Leg						
185	50	177	69.7	-008	69.0	69.0
185	52	176	72.6	-009	71.7	69.7
185	49	175	69.1	-010	68.0	69.0
185	50	174	69.3	-011	68.0	68.0
185	50	175	70	-010	68.9	68.9
181	51	172	72.4	-009	71.5	70.5
180	51	172	71.6	-008	70.9	69.9
Second Leg						
005	50	020	72.2	015	69.7	69.7
004	50	019	71.3	015	68.8	68.8
006	50	019	71.2	013	69.3	69.3
005	50	020	71.1	015	68.6	68.6
005	50	019	74.1	014	71.8	71.8
004	51	020	73.9	016	71.0	70.0
005	50	020	73	015	70.5	70.5
001	51	018	72.4	017	69.2	68.2

3. Adjust true airspeed by difference in actual indicated airspeed and aim airspeed (this adjustment assumes that the size of an indicated knot and a true knot are the same for small changes). By doing this step, all true airspeeds will correspond to the same indicated airspeed, even though the actual data may have varied slightly.

$$V_{adj} = V + (V_{aim} - V_i)$$

See Table D1 for results.

4. Average all adjusted true airspeeds to determine true airspeed corresponding to aim airspeed.

$$V = 69.5 \text{ KTAS}$$

5. Find ambient temperature.

$$T_a = T_i - \frac{KV^2}{2C_p} * \left(\frac{6080 \text{ ft / nm}}{3600 \text{ sec/ hr}}\right)^2 + 460$$

$$T_a = 520.1° \text{ R}$$

6. Find temperature ratio (T/T_{sl}).

$$\theta_t = \frac{T_a}{T_{sl}}$$

$$\theta_t = 1.0021$$

7. Find Mach Number based on measured true airspeed.

$$M = \frac{V}{a_{sl}\sqrt{\theta_t}}$$

$$M = 0.1050$$

8. Find instrument corrected altitude

$$h_{ic} = h_i + \Delta h_{ic}$$

$h_{ic} = 9000$ feet (for this test, assume $\Delta h_{ic} = 0$)

9. Find instrument corrected airspeed

$$V_{ic} = V_{aim} + \Delta V_{ic}$$

$V_{ic} = 50$ KIAS (for this test, assume $\Delta V_{ic} = 0$)

10. Find pressure ratio (P/P_{sl}).

$$\delta_{ic} = (1 - 6.87559\text{x}10^{-6}\, h_{ic})^{5.2559}$$

$$\delta_{ic} = 0.7148$$

11. Find Mach number based on indicated airspeed and pressure altitude.

$$M_{ic} = \sqrt{5[(\frac{1}{\delta_{ic}}\{[1+0.2(\frac{V_{ic}}{a_{sl}})^2]^{3.5} - 1\} + 1)^{2/7} - 1]}$$

$$M_{ic} = 0.0894$$

12. Find the Mach position correction.

$$\Delta M_{pc} = M - M_{ic}$$

$$\Delta M_{pc} = 0.0156$$

13. Find the temperature ratio at standard altitude to convert flight test corrections to standard altitude.

$$\theta_{s_{std}} = (1 - 6.87559\text{x}10^{-6}\, h_{std})$$

$$\theta_{s_{std}} = 1$$

14. Find altitude position correction.

$$\Delta H_{pc} = \frac{\theta_{s_{std}}}{3.61382\text{x}10^{-5}} \frac{\gamma M_{ic} \Delta M_{pc}}{1 + 0.2M_{ic}^2}$$

$\Delta H_{pc} = 53.9$ feet

15. Find airspeed position correction.

$$\Delta V_{pc} = \frac{a_{sl}^2 \delta_{ic}}{\left[1 + 0.2\left(\frac{V_{ic}}{a_{sl}}\right)^2\right]^{2.5} V_{ic}} \frac{M_{ic} \Delta M_{pc}}{1 + 0.2M_{ic}^2}$$

$\Delta V_{pc} = 8.7$ knots

CLIMB PERFORMANCE

Test Procedures:

Climb data were collected using the sawtooth climb flight test technique (FTT). The data band was ±500 feet from the test altitude. Prior to starting the tests, the crosswind headings were determined using the method described previously under GPS Ground Speed Method. The altimeter was set at 29.92 in Hg to indicate pressure altitude.

Starting approximately 500 feet below the data band (1000 feet below the test altitude), full throttle was applied and the nose pulled up as required to stabilize in a climb at the aim airspeed on a crosswind heading. Entering the data band, the pilot called a time hack followed by indicated airspeed at each 100 foot altitude increment. At each time hack, the flight test engineer recorded the time using the Hewlett Packard 48SX calculator. This calculator had a real time clock, and pressing the appropriate key caused the current time to be stored in the calculator's memory. During the climb, MAP, RPM, fuel used, and any deviations from aim airspeed were recorded. Passing through the test altitude, the Vertical Velocity Indicator (VVI) reading was recorded as a cross check. The OAT at test altitude was also recorded. Airspeed was maintained ±2 knots.

Upon climbing through the top of the data band, the pilot continued the climb to approximately 500 feet above the data band to set up for a sawtooth descent. Above the data band the pilot was allowed to vary airspeed as desired. The flight test engineer recorded on the flight card the last time entered on the 48SX calculator to ensure that the proper times were recorded for each test point after the flight.

Following a sawtooth descent, another sawtooth climb was flown on the reciprocal heading to minimize wind effects on the data. Turns to reciprocal headings were done either above or below the data band as required to remain inside the assigned airspace.

After the flight, the times for each altitude increment were hand copied from the 48SX calculator to the flight card.

Data Reduction Methods:

Sawtooth climb data were analyzed by adjusting the *RPM* model, as described in Appendix C, until the model accurately predicted flight test data at several non-standard conditions. Test day rate of climb values were found by plotting altitude against time as shown in Figure D7. A line was manually fitted to the data which best represented the rate of climb. The slope of this line was taken as the rate of climb.

Data Presentation:

Figure A34 through Figure A39 present climb data for non-standard conditions. The pressure altitude and temperature scales on the left side of the charts do not represent a density altitude conversion as on the cruise charts. These scales represent the actual changes necessary to correct for non-standard conditions, and are different on each chart.

These charts were created from *RPM* model output for climbs at temperature deviations from standard of -80° F, -40° F, 0° F, +40° F, and +80° F. The lines on the right side of the chart are the data for the climb at standard temperature. To build the left hand side of the chart, consider the rate of climb chart. To draw the lines of constant pressure altitude, the first point would be drawn at the standard temperature as the x coordinate and the pressure altitude as the y coordinate. The x coordinate of the next point would be the temperature at the pressure altitude on the non-standard day (i.e. standard + deviation). The y coordinate is found by first looking at the non-standard day rate of climb at the desired pressure altitude. Using this rate of climb, the standard day data is consulted to determine the pressure altitude that had the same rate of climb on a standard day. This altitude from the standard day data becomes the y coordinate. This process is repeated until all temperature deviations at all pressure altitudes are plotted. The same procedure was used to build the time to climb/fuel to climb and the distance to climb charts.

The variation of rate of climb and fuel flow with non-standard conditions were essentially the same, so both values are shown on the same chart. Likewise, the variation of time to climb and fuel to climb were essentially the same, so both values are shown on the same chart. The variation of distance to climb was slightly different from time and fuel to climb, as can be seen by comparing the left sides of Figure A35 and

Figure A36. However, distance can be plotted with time and fuel with no more than approximately 5% error, as was done for the Flight Manual inputs.

DESCENT PERFORMANCE

Test Procedures:

Descent data were collected using the sawtooth descent FTT. The data band was ±500 feet from the test altitude. Prior to starting the tests, the crosswind headings were determined using the method described previously under GPS Ground Speed Method. The altimeter was set at 29.92 in Hg to indicate pressure altitude. A sawtooth descent was normally done after each sawtooth climb.

Starting approximately 500 feet above the data band (1000 feet above the test altitude), the throttle was set as required (idle or 2250 RPM). The nose was pushed over as required to stabilize in a descent at the aim airspeed on a crosswind heading. Entering the data band, the pilot called a time hack followed by indicated airspeed at each 100 foot altitude increment. At each time hack, the flight test engineer recorded the time using the Hewlett Packard 48SX calculator. This calculator had a real time clock, and pressing the appropriate key caused the current time to be stored in the calculator's memory. During the descent, RPM, fuel used, and any deviations from aim airspeed were recorded. Fuel flow was estimated by mentally averaging the indicated fuel flow from the fuel totalizer. Passing through the test altitude, the Vertical Velocity Indicator (VVI) reading was recorded as a cross check. The OAT at test altitude was also recorded. Airspeed was maintained ±2 knots. MAP was not recorded, as the indicated MAP was well below the bottom of the scale shown on the MAP gauge.

Upon descending through the bottom of the data band, the pilot continued the descent to approximately 500 feet below the data band to set up for a sawtooth climb. Below the data band the pilot was allowed to vary airspeed as desired. The flight test engineer recorded on the flight card the last time entered on the 48SX calculator to ensure that the proper times were recorded for each test point after the flight.

Following a sawtooth climb, another sawtooth descent was flown on the reciprocal heading to minimize wind effects on the data. Turns to reciprocal headings were done either above or below the data band as required to remain inside the assigned airspace.

After the flight, the times for each altitude increment were hand copied from the 48SX calculator to the flight card.

Data Reduction Methods:

Example Data:

$V_i = 80$ KIAS

Test $h_{ic} = 6000$ ft

$T_i = 71°$ F

$W_t = 1721$ lbs

Wing Area = 160 ft^2

Temperature Recovery Factory (K) = 0.8

1. Find the airspeed position correction from the flight test derived position correction chart (Figure A27).

At 80 KIAS, $\Delta V_{pc} = -0.5$ knots

2. Find the calibrated airspeed.

$$V_{pc} = V_i + \Delta V_{pc}$$

$$V_{pc} = 79.5 \text{ KCAS}$$

3. Find pressure ratio (P/P_{sl}).

$$\delta_{ic} = (1 - 6.87559\times10^{-6}\, h_{ic})^{5.2559}$$

$$\delta_{ic} = 0.8014$$

6. Find Mach Number.

$$M = \sqrt{5\left[\left(\frac{1}{\delta_{ic}}\left\{\left[1+0.2\left(\frac{V_{pc}}{a_{sl}}\right)^2\right]^{3.5} - 1\right\}+1\right)^{2/7} - 1\right]}$$

$M = 0.1342$

7. Find ambient temperature.

$$T_a = \frac{T_i + 460}{1 + 0.2KM^2}$$

$T_a = 529.5° R$

8. Find temperature ratio (T/T_{sl}).

$$\theta_t = \frac{T_a}{T_{sl}}$$

$\theta_t = 1.0202$

9. Find density ratio (ρ/ρ_{sl}).

$$\sigma_t = \frac{\delta_t}{\theta_t}$$

$\sigma_t = 0.7855$

10. Find altitude position correction.

$$h_{pc} = h_i + \frac{V_c^2 - V_i^2}{2\sigma_t g} * \left(\frac{6080 \text{ ft / mi}}{3600 \text{ sec/ hr}}\right)^2$$

$h_{pc} = 5996$ feet

11. Find standard temperature ratio at test altitude.

$\theta_s = 1 - 6.87559 \times 10^{-6}\ h_{ic}$

$\theta_s = 0.95877$

12. Find true airspeed.

$$V = Ma_{sl}\sqrt{\theta_t}$$

$V = 151$ ft/sec

13. Find equivalent airspeed.

$$V_e = V_t\sqrt{\sigma_t} * \frac{3600 \text{ sec/ hr}}{6080 \text{ ft / nm}}$$

$V_e = 79.4$ KEAS

14. Find average rate of descent by plotting altitude against time as shown in Figure D8. Fit a line to the data which best represents the rate of descent. The slope of this line is the rate of descent. Do this for both descents at the current conditions and average the results.

Test $ROD_1 = -976$ ft/min

Test $ROD_2 = -871$ ft/min

$ROD_t = -924$ ft/min $= -15.4$ ft/sec

15. Find the density corrected rate of descent. This step converts the rate of descent from a pressure altitude rate of descent to a tapeline altitude rate of descent by accounting for expansion and contraction of pressure layers at non-standard temperature.

$$ROD_d = ROD_t\sqrt{\frac{\theta_t}{\theta_s}}$$

$ROD_d = -15.9$ ft/sec

16. Find Lift Coefficient.

$$C_L = \frac{2W_t}{\rho_{sl} V_e^2 S} * \left(\frac{3600 \text{ sec/ hr}}{6080 \text{ ft / nm}}\right)^2$$

$C_L = 0.5031$

17. Find Drag Coefficient.

$$C_D = \frac{ROD_d}{V}\frac{2W_t}{\rho_{sl}\sigma_t V^2 S}$$

$C_D = 0.05279$

18. Find L/D ratio.

$$\frac{L}{D} = \frac{C_L}{C_D}$$

L/D = 9.53

Data Presentation:

Figure A45 through Figure A50 present descent data for non-standard conditions. These charts were created by calculating descent data at temperature deviations from standard of -80° F, -40° F, 0° F, +40° F, and +80° F. The lines on the right side of the chart are the data for the descent at standard temperature. To build the left hand side of the chart, consider the rate of descent chart. To draw the lines of constant pressure altitude, the first point would be drawn at the standard temperature as the x coordinate and the pressure altitude as the y coordinate. The x coordinate of the next point would be the temperature at the pressure altitude on the non-standard day (i.e. standard + deviation). The y coordinate is found by first looking at the non-standard day rate of descent at the desired pressure altitude. Using this rate of descent, the standard day data is consulted to determine the pressure altitude that had the same rate of descent on a standard day. This altitude from the standard day data becomes the y coordinate. This process is repeated until all temperature deviations at all pressure altitudes are plotted. The same procedure was used to build the time to descend/fuel to descend and the distance to descend charts.

The variation of rate of descent and fuel flow with non-standard conditions were essentially the same, so both values are shown on the same chart. Likewise, the variation of time to descend and fuel to descend were essentially the same, so both values are shown on the same chart. The variation of distance to descend was significantly different from time and fuel to descend, as can be seen by comparing the left sides of Figure A46 and Figure A47. Therefore, distance to descend was plotted separately.

TAKEOFF PERFORMANCE

Test Procedures:

Takeoff data were collected using the average acceleration FTT. If a constant acceleration was assumed from brake release to liftoff, then the ground roll distance could be calculated knowing the liftoff speed and the elapsed time for the takeoff.

Prior to takeoff, the runway number was recorded. The pressure altitude was found by temporarily setting the altimeter to 29.92 in Hg. OAT was read from the aircraft's OAT gauge. Fuel used was recorded from the fuel totalizer. For flights at the USAF Academy, wind speed and direction were given immediately prior to takeoff by the control tower. For flights away from the USAF Academy, wind data was recorded from the local Automated Weather Observation System (AWOS) broadcast.

The pilot announced brake release and a stopwatch was started. The pilot then announced the liftoff and noted the liftoff airspeed. At liftoff, the stopwatch was stopped and the time and airspeed recorded.

Data Reduction Methods:

Example Data:

h_{pc} = 6060 ft

T_i = 26° F

W_t = 1791 lbs

Runway Heading = 337°

Runway slope = 0°

Wind Direction = 360°

Wind Speed = 9 knots

V_i = 55 KIAS

t = 23.53 sec

Standard Weight = 1760 lbs

Standard Altitude = Sea Level

1. Find ambient temperature.

$$T_a = T_i + 460$$

$$T_a = 486° R$$

2. Find pressure ratio (P/P_{sl}).

$$\delta_t = (1 - 6.87559x10^{-6} h_{pc})^{5.2559}$$

$$\delta_t = 0.7996$$

3. Find temperature ratio (T/T_{sl}).

$$\theta_t = \frac{T_a}{T_{sl}}$$

$$\theta_t = 0.9364$$

4. Find density ratio (ρ/ρ_{sl}).

$$\sigma_t = \frac{\delta_t}{\theta_t}$$

$$\sigma_t = 0.8539$$

5. Find the airspeed position correction from the flight test derived position correction chart (Figure A27) at liftoff airspeed.

At 55 KIAS, $\Delta V_{pc} = 5$ knots

6. Find the calibrated airspeed at liftoff.

$$V_{pc} = V_i + \Delta V_{pc}$$

$$V_{pc} = 60 \text{ KCAS}$$

7. Find Mach Number at liftoff.

$$M = \sqrt{5\left[\left(\frac{1}{\delta_t}\left\{\left[1+0.2\left(\frac{V_{pc}}{a_{sl}}\right)^2\right]^{3.5} - 1\right\} + 1\right)^{2/7} - 1\right]}$$

$$M = 0.1014$$

8. Find true airspeed at liftoff.

$$V_1 = Ma_{sl}\sqrt{\theta_t}$$

$$V_1 = 110 \text{ ft/sec}$$

9. Find angle of wind.

AOW = Wind Direction - Runway Heading

AOW = 23°

10. Find headwind component.

$$V_w = \text{Wind Speed} * \cos(\text{AOW}) * \frac{6080 \text{ ft / nm}}{3600 \text{ sec/ hr}}$$

$$V_w = 14.0 \text{ ft/sec}$$

11. Find ground speed at liftoff.

$$V_{G_1} = V_1 - V_w$$

$$V_{G_1} = 95.6 \text{ ft/sec}$$

12. Find actual ground roll.

$$S_{G_1} = 0.5 * V_{G_1} * t$$

$$S_{G_1} = 1124 \text{ feet}$$

13. Convert standard liftoff airspeed of 62 KCAS (57 KIAS) to true airspeed at ambient temperature.

$$V_2 = \frac{62 \text{ KCAS}}{\sqrt{\sigma_t}} * \frac{6080 \text{ ft / nm}}{3600 \text{ sec/ hr}}$$

$$V_2 = 113 \text{ ft/sec}$$

14. Find ground speed corresponding to standard liftoff airspeed.

$$V_{G_2} = V_2 - V_w$$

$$V_{G_2} = 99.3 \text{ ft/sec}$$

15. Find time to accelerate to standard liftoff airspeed.

$$t_c = t\frac{V_{G_2}}{V_{G_1}}$$

$t_c = 24.45$ sec

16. Find ground roll corrected to standard liftoff airspeed.

$$S_{G_c} = 0.5 * V_{G_2} * t_c$$

$S_{G_c} = 1214$ feet

17. Correct for runway slope to find takeoff distance on a level runway.

$$S_{level} = \frac{S_{G_c}}{1+\left(\frac{2gS_{G_c}\sin\theta}{V_2^2}\right)}$$

where θ is the runway slope from horizontal (+ uphill, - downhill) measured in angular measurement, not percent slope.

$S_{level} = 1214$ feet

18. Correct for headwind to find takeoff distance with no wind.

$$S_w = S_{level}\left(\frac{V_{G_1}+V_w}{V_{G_1}}\right)^{1.85} = S_{level}\left(\frac{V_1}{V_{G_1}}\right)^{1.85}$$

$S_w = 1564$ feet

19. Correct for weight to find takeoff distance at standard weight.

$$S_{wt} = S_w\left(\frac{W_s}{W_t}\right)^{2.4}$$

$S_{wt} = 1500$ feet

20. Correct for altitude to find takeoff distance at standard altitude.

$$S_{std} = S_{wt}\left(\frac{\sigma_s}{\sigma_t}\right)^{-2.4}$$

$S_{std} = 1026$ feet

Data Presentation:

The mean takeoff ground roll shown in Figure A52 is shown in a format similar to that used by several general aviation manufacturers. This chart is created basically by reversing the data standardization process.

After standardizing all of the takeoff data, ideally every takeoff would standardize to the same distance as all of the other takeoffs, which would be the takeoff distance at sea level, at standard weight, with no wind on a level runway. Of course, the result is a distribution with a mean and a standard deviation. Starting with this mean takeoff distance, the density correction is created by varying pressure altitude and temperature to change the density ratio in the equation

$$S_{wt} = \frac{S_{std}}{\left(\frac{\sigma_s}{\sigma_t}\right)^{-2.4}}$$

The weight correction guide lines are created by selecting a distance at standard weight (S_{wt}). This distance is the value of the curve at the weight reference line. The remainder of the curve is formed by varying W_t in the equation

$$S_w = \frac{S_{wt}}{\left(\frac{W_s}{W_t}\right)^{2.4}}$$

The wind correction guide lines are created by selecting a distance at zero wind (S_w). This distance is the value of the curve at the wind reference line. The remainder of the curve is formed by varying V_w in the equation

$$S_{level} = \frac{S_W}{\left(\frac{V}{V-V_W}\right)^{1.85}}$$

where V is the takeoff true airspeed.

The dispersion charts shown in Figure A53 and Figure A54 were created using the standard deviation of the standardized takeoff distances. Assuming the takeoff data were normally distributed, a one-tailed test was used, since takeoffs shorter than the mean distance are not a operational concern. For a 95 percent confidence interval, the normal distribution gives a z = 1.65. For a 99 percent confidence interval, the normal distribution gives a z = 2.33. Multiplying the standard deviation by the appropriate z value gives the dispersion at sea level, at standard weight, with no wind on a level runway. To adjust the dispersion for density, the density ratio was varied in the following equation, where S_{std} was the dispersion at standard conditions.

$$S_{wt} = \frac{S_{std}}{\left(\frac{\sigma_s}{\sigma_t}\right)^{-2.4}}$$

To adjust for weight, W_t in the following equation is varied.

$$S_W = \frac{S_{wt}}{\left(\frac{W_s}{W_t}\right)^{2.4}}$$

No correction is made for headwind, since any headwind would shorten the takeoff run, so

$$S_{level} = S_w$$

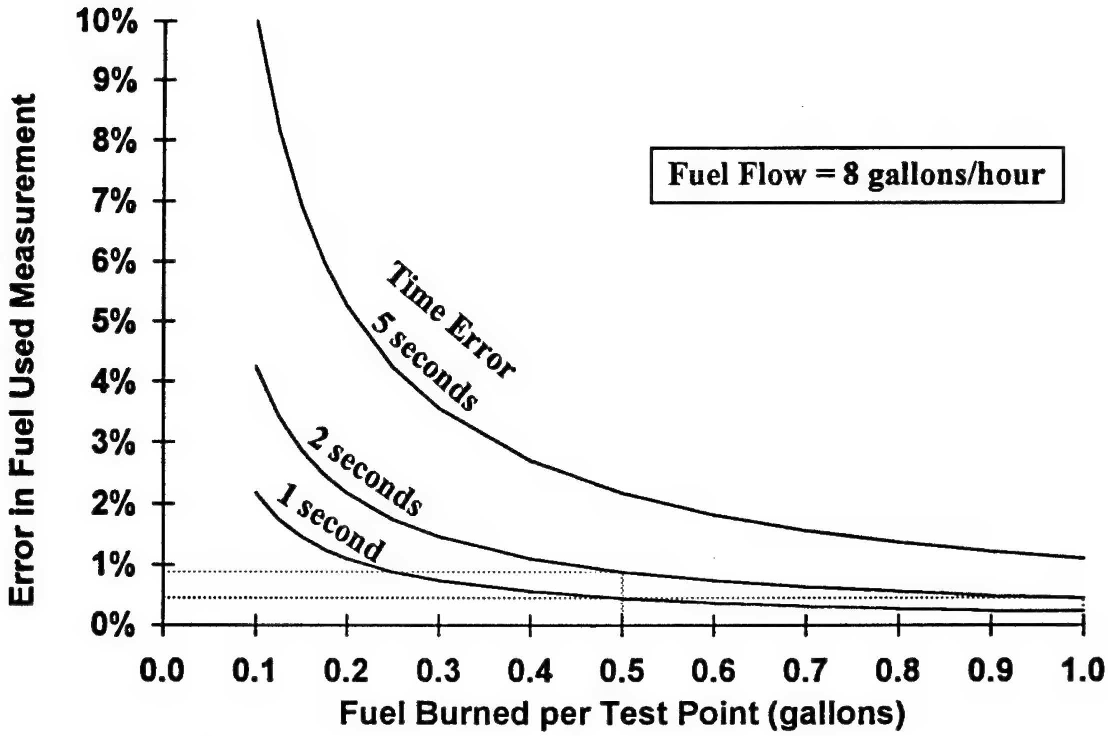

Figure D1 Determining Fuel Burn Amount for Cruise Test Points

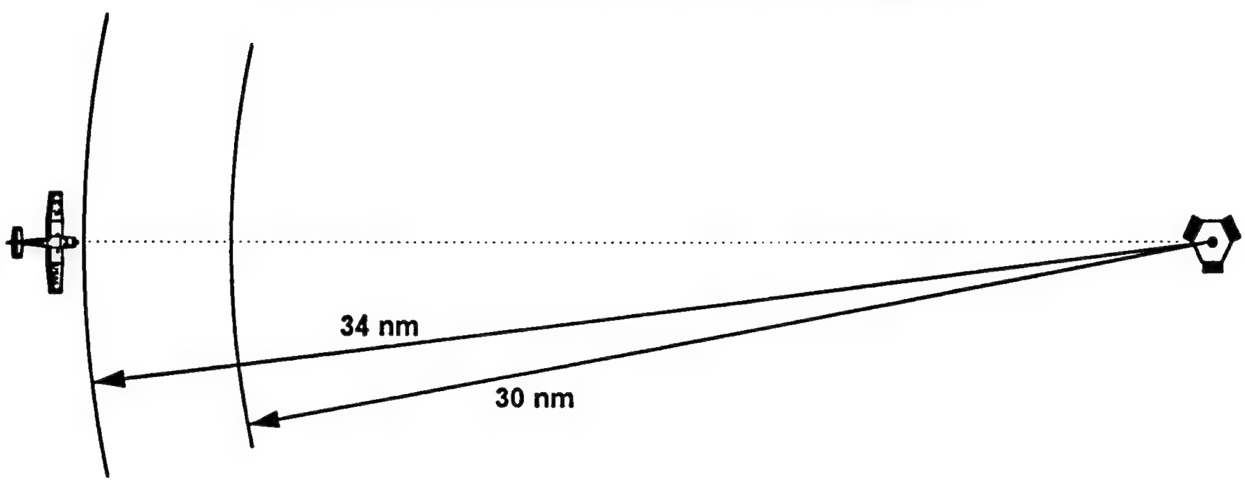

Figure D2 GPS Speed Course Distance Arcs

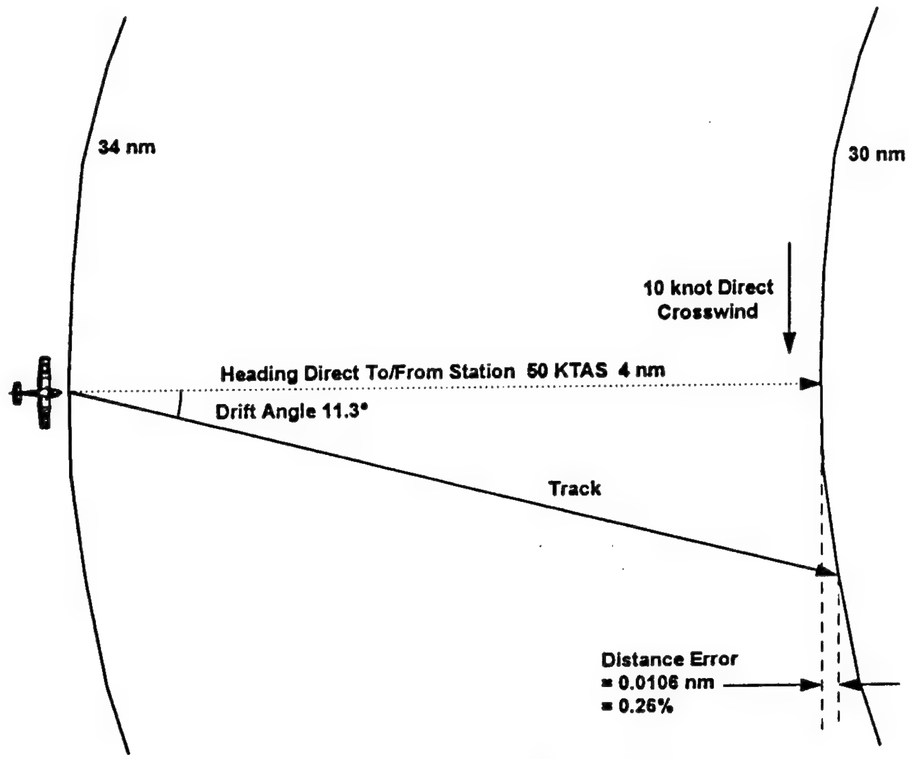

Figure D3 GPS Speed Course Wind Drift Error

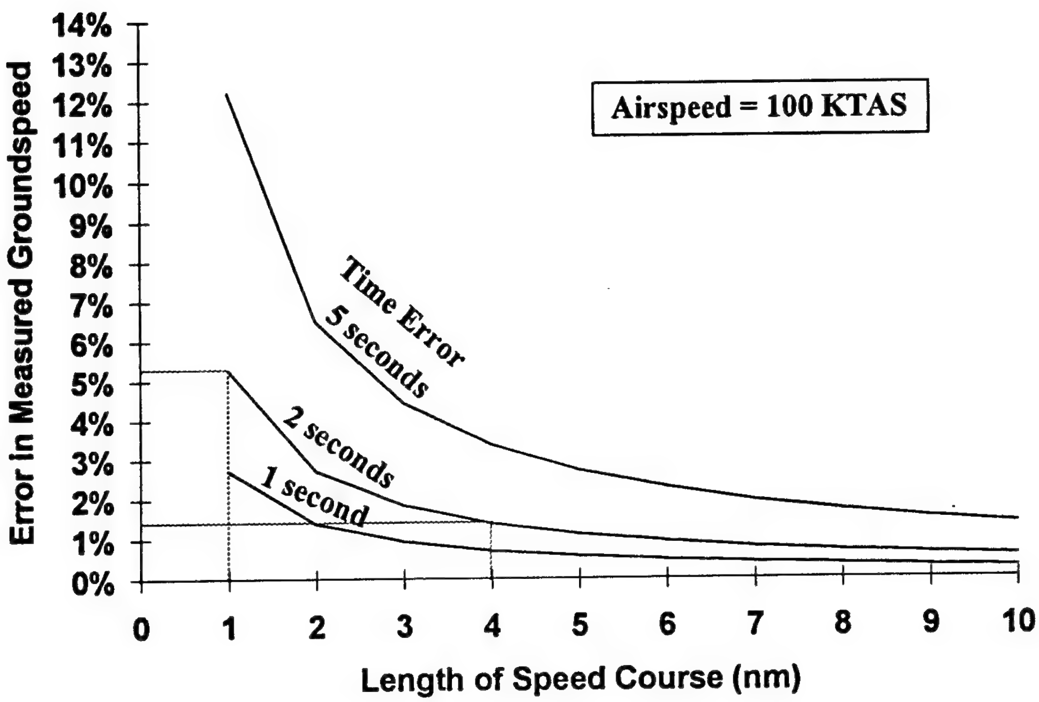

Figure D4 Determining Leg Length for GPS Speed Course Test Points

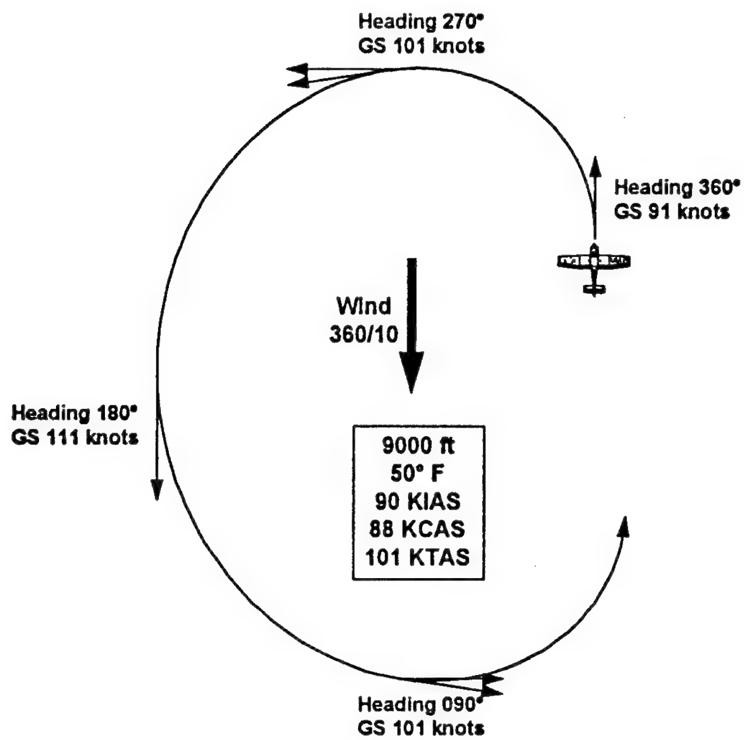

Figure D5 Ground Speed Variation in a Turn

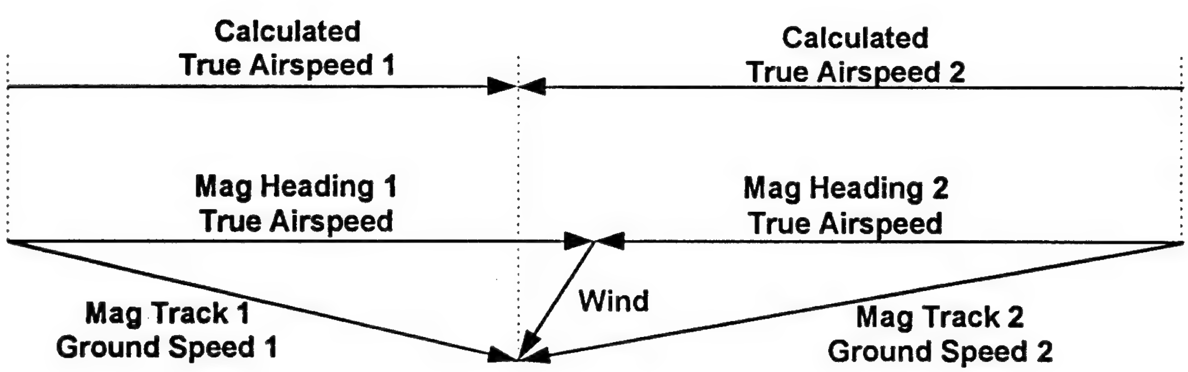

Figure D6 GPS Ground Speed Method Vector Diagram

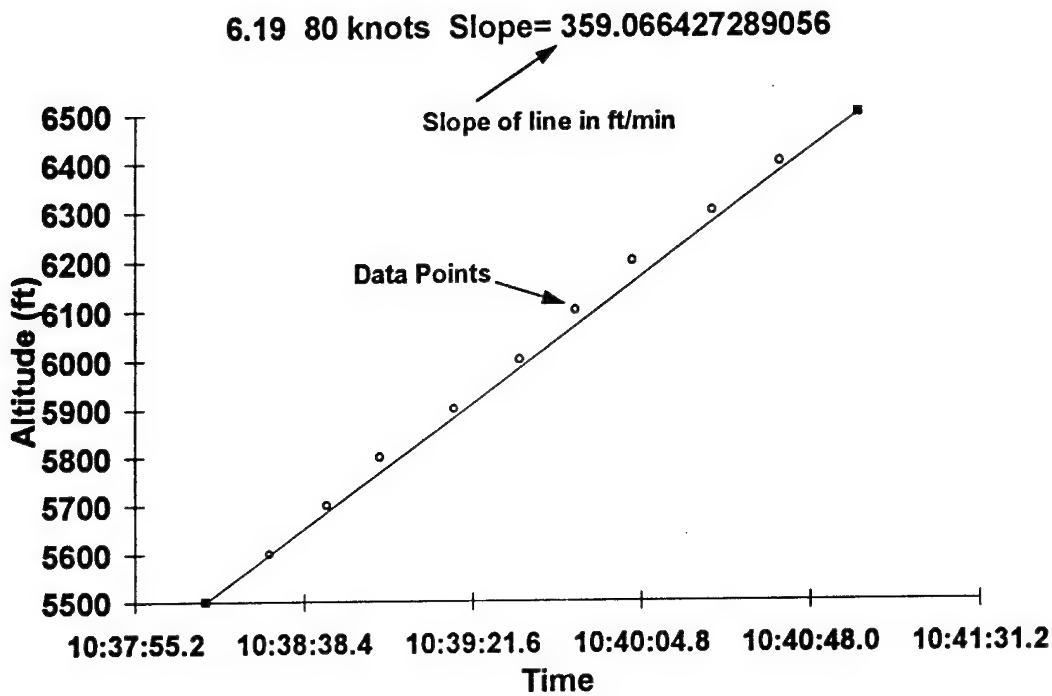

Figure D7 Finding Test Day Rate of Climb

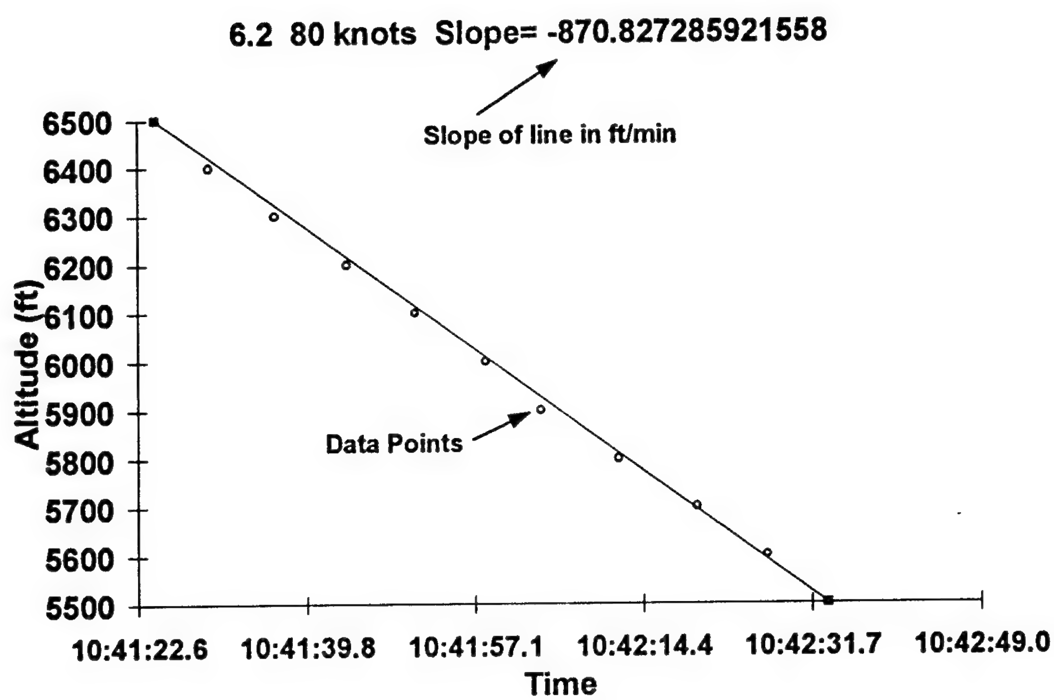

Figure D8 Finding Test Day Rate of Descent

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Definition	Units
AOW	angle of wind	deg
a_{sl}	speed of sound at sea level	1116.4 ft/sec
AWOS	Automated Weather Observation System	---
BHP	brake horsepower	---
BHP_{iw}	standardized brake horsepower required	hp
BHP_t	test brake horsepower	hp
BSFC	brake specific fuel consumption	hp/lb/hr
C	Celsius	deg
c_1	constant of convenience	---
c_2	constant of convenience	---
CAS	calibrated airspeed	knots
CCFT	Cadet Competition Flying Team	---
C_D	drag coefficient	unitless
C_{D_o}	parasite drag coefficient	unitless
C_L	lift coefficient	unitless
C_p	power coefficient	unitless
C_p	specific heat at constant pressure	6009 $ft^2/sec^2/°R$
C_q	torque coefficient	unitless
C_t	thrust coefficient	unitless
D	drag	lbs
D	propeller diameter	ft
$\Delta D_{slipstream}$	additional drag from slipstream	lbs
deg	degree	---
F	Fahrenheit	deg
FAA	Federal Aviation Administration	---
FTS	Flying Training Squadron	---
FTT	flight test technique	---
ft	feet	---
GPH	gallons per hour	---
GPS	Global Positioning System	---
g	acceleration of gravity	32.2 ft/sec^2

Abbreviation	Definition	Units
gal	gallon	---
h_i	indicated altitude	ft
h_{ic}	indicated altitude corrected for instrument error	ft
HP, hp	horsepower	---
h_{pc}	altitude corrected for instrument and position error	ft
h_{std}	standard altitude	ft
Δh_{ic}	altitude instrument correction	ft
ΔH_p	change in pressure altitude	ft
ΔH_{pc}, Δh_{pc}	altitude position correction	ft
ΔH_{tl}	change in tapeline altitude	ft
hr	hour	---
IAS	indicated airspeed	knots
IFR	Instrument Flight Rules	---
in Hg	inches of mercury	---
J	advance ratio	unitless
K	induced drag coefficient	unitless
KCAS	knots calibrated airspeed	---
KEAS	knots equivalent airspeed	---
KIAS	knots indicated airspeed	---
KTAS	knots true airspeed	---
L	lift	lbs
L/D	lift to drag ratio	unitless
lbs	pounds	---
M	Mach number	unitless
MAP	manifold pressure	in Hg
MAP_{max}	full throttle MAP	in Hg
$MAP_{max_{sl}}$	full throttle MAP at sea level standard day	in Hg
$\dot{m}_{air}$	mass flow rate of air	slugs/sec
M_{ic}	indicated Mach number corrected for instrument error	unitless
min	minute	---
ΔM_{pc}	Mach position correction	unitless
nm	nautical miles	---
OAT	outside air temperature	°F

Abbreviation	Definition	Units
P	static pressure	lb/ft^2
PA	pressure altitude	ft
P_{iw}	standardized power required	hp
P_{sl}	standard day sea level pressure	2116 lb/ft^2
P_T	total pressure	lb/ft^2
ΔP	change in pressure	lb/ft^2
ΔP_s	static pressure error	lb/ft^2
R	universal gas constant	1716 lb-ft/slug/°R
R	range	nm
R	Rankine	deg
ROC	rate of climb	ft/min
$ROC_{pressure}$	rate of climb in pressure altitude	ft/min
ROC_{tl}	rate of climb in tapeline altitude	ft/min
ROD	rate of descent	ft/min
ROD_t	test day rate of descent	ft/min
ROD_d	rate of descent corrected for density effects	ft/min
RPM	Reciprocating Engine and Propeller Modeling Program	---
RPM	revolutions per minute	---
S	wing reference area	ft^2
SAR	specific air range	nm/gal
SE	specific endurance	hr/gal
S_G	takeoff ground roll distance	ft
S_{level}	takeoff ground roll distance corrected for runway slope	ft
S_{std}	standardized takeoff ground roll distance	ft
S_w	takeoff ground roll distance corrected for wind	ft
S_{wt}	takeoff ground roll distance corrected for weight	ft
T	temperature	°F, °R
t	time	sec
t_c	time to accelerate to standard liftoff airspeed	sec
T_a	ambient temperature	°F, °R
T_i	indicated temperature	°F, °R
TPS	Test Pilot School	---
T_s	standard day temperature	°F, °R

Abbreviation	Definition	Units
T_{sl}	standard sea level temperature	59° F, 519° R
T_t	test day temperature	°F, °R
USAF	United States Air Force	---
USAFA	United States Air Force Academy	---
V	true airspeed	knots, ft/sec
V_{adj}	adjusted airspeed	knots
V_e	equivalent airpseed	knots
VFR	Visual Flight Rules	---
V_G	ground speed	knots
V_i	indicated airspeed	knots
v_i	propeller induced velocity	ft/sec
V_{ic}	indicated airspeed corrected for instrument error	knots
ΔV_{ic}	airspeed instrument error	knots
$v_{i_{level}}$	propeller induced velocity in level unaccelerated flight	ft/sec
V_{iw}	standardized equivalent airspeed	knots
V_{NO}	maximum structural cruising speed	knots
VOR	VHF Omnidirectional Range	---
V_{pc}	airspeed corrected for position error	knots
ΔV_{pc}	airspeed position correction	knots
VVI	vertical velocity indicator	---
V_w	headwind component of wind speed	knots
W	weight	lbs
W_s	standard weight	lbs
W_t	test weight	lbs
$\dot{w}_f$	fuel flow	gal/hr
$\dot{w}_{f_s}$	standardized fuel flow	gal/hr
$\dot{w}_{f_t}$	test day fuel flow	gal/hr
%	percent	---
γ	ratio of specific heats	1.4 (air)
δ_{ic}	pressure ratio for h_{ic}, P/P_{sl}	unitless
δ_t	test day pressure ratio, P/P_{sl}	unitless
η_p	propeller efficiency	unitless
η_{vol}	volumetric efficiency	unitless

Abbreviation	Definition	Units
ρ	density	slugs/ft^3
ρ_s	standard day density	slugs/ft^3
ρ_{sl}	standard day sea level air density	0.0023769 slugs/ft^3
ρ_t	test day density	slugs/ft^3
σ	density ratio, ρ/ρ_{sl}	unitless
σ_s	standard day density ratio, ρ/ρ_{sl}	unitless
σ_t	test day density ratio, ρ/ρ_{sl}	unitless
θ_s	standard day temperature ratio, T/T_{sl}	unitless
$\theta_{s_{std}}$	standard day temperature ratio at standard altitude, T/T_{sl}	unitless
θ_t	test day temperature ratio, T/T_{sl}	unitless